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The Sidereal Universe—I*

Theories Regarding Its Constitution, Structure and Motions

By J. S. Plaskett

THE determination of the constitution, the structure, and the motions of the universe is the ultimate aim of all astronomical research. It is undoubtedly true that the last ten or fifteen years have seen greater development of our ideas and the growth of a more precise knowledge of the universe, especially with reference to the constitution, motions, and arrangements of the stars, than all previous time. Such a development with regard to their positions and motions, at any rate, has only been rendered possible by the labors of the early astronomers who painstakingly and accurately, and with a knowledge that they could never see the full fruits of their labors, mapped the positions of the stars. They thus obtained, by the comparison of these positions with those of the present, an accurate determination of their proper mot ons, their change of position in the sky. The name of Boss, to whose genius and painstaking the cataloguing of the proper motions of the brighter stars is due, is intimately connected with this part of the data on which generalizations as to the structure of the universe is based.

Of almost equal importance with the proper or cross motions of the stars in the solution of this problem, is their velocity in the radius vector, in the line-of-sight, toward or from us. Unlike proper motions, which for accurate values require long separated observations of the positions of the stars, a single observation by the spectroscope gives the radial velocity. The main work of the Lick Observatory for the past fifteen years has been the determination of the radial velocities of the brighter stars, and the name of Campbell will always be associated with this important work. Within the last three years, the radial velocities of some 1,500 stars, the great majority of which have been determined at L ck, have been published by him.

It is evident, however, that one other factor is necessary to determine the complete motion and position of the stars, and this is their distance. The determination of the parallax, the angle subtended at the star by the distance between the earth and the sun, from which the linear distance is readily determined, is one of the most difficult and exacting of all astronomical measurements. This is owing to the enormous distances and corresponding small angles to be observed, the greatest angle involved (that from the nearest star, Alpha Centauri) being equal to the angle between two points a quarter of an inch apart at the distance of a mile. The relative errors in these measurements are therefore much greater than in the other two factors. Numerous astronomers have been engaged for some years in this work, and the sum of their endeavors is that the parallax or distance of about 350 stars has been determined with fairly satisfactory precision. This number has been considerably added to by indirect methods; but undoubtedly the greatest need to-day is a reasonably accurate determination of the distance of many more stars. After the determination of these fundamental factors of the stars' positions and motions, the work of calculation and generalization begins, and to this, many investigators of the first rank have given their labors. Foremost among these must probably be placed Kapteyn, who by his statistical studies has led the way to many important results. But Dyson, Eddington, Campbell, Russell, Schwarzschild, and others, have by their labors on the structure and motions of the universe added markedly to our knowledge.

Before summarizing the most important results of these investigations and generalizations concerning the geometrical and dynamical relations in the universe, it will be desirable to devote some time to the consideration of the physical nature and constitution of its individual members; especially as the two branches, the astronomical and the astrophysical, are intimately associated. The same instrument—the spectroscope—which tells us the velocity of approach or recession of the heavenly bodies also gives us exact and certain information as to their constitution and physical condition. This marvelous instrument, probably the most potent factor in unraveling the mystery of the universe ever discovered, tells us equally well for the nearest or most distant celestial objects, provided only sufficient light is available, and by the analysis—in an instant, as it were—of the inherent character of this light, the radial velocity, the chemical constitution, and the physical condition of their outer radiating surfaces. Just as the name of Campbell is connected with the determination of the radial velocities, so is the name of Pickering, doing at the same time full justice to the pioneer researches of Huggins and Vogel, associated with the determination of the constitution of the heavenly bodies and the classification of their spectra into well-defined types. The researche at the Harvard Observatory on the spectra of the stars have been made with the objective prism spectroscope, which, unlike the slit spectroscope used in radial-velocity determinations, with which the spectrum of only one star can be photographed at a time, enables some hundreds of spectra to be photographed on a single plate. Over one hundred thousand stellar spectra have thereby been obtained. The discussion of this vast quantity of material has resulted in a system of classification by which more than 99 per cent of the spectra can be arranged in six main types or groups, which have been designated by the letters *B*, *A*, *F*, *G*, *K*, *M*.

In order that what is to follow may be more readily understood by those not familiar with stellar spectra, it is desirable to describe briefly the various types of spectra. In the first place, the great majority of these spectra are crossed by dark lines, and are absorption spectra. This indicates the important fact that the stars in general are incandescent, glowing bodies, whose outer and less dense atmospheres are at lower temperatures than the interior, and produce these absorption-lines in the spectra. Even if nothing more than this were determined by the spectroscope, it would be a conclusion of great importance. In addition to that, as is well known, the positions of these lines, by comparison with the spectra of the terrestrial elements, enable identifications of the elements present in the atmospheres of the stars to be made. Comparing the different types in this way, we find that they are arranged in an orderly sequence, the *B* type having comparatively simple spectra, with few lines, mostly corresponding to the elements helium and hydrogen. In the *A* stars helium disappears and we have hydrogen and a few of the metals. In the succeeding types, the metallic lines become stronger and more numerous, more and more metals being represented, and the relative intensity of the hydrogen decreases. At the same time, while the *B* and *A* stars are intensely white or bluish-white, the succeeding types become yellowish, yellow-orange, and red. As examples, we have Rigel, of the *B*; Vega or Sirius, *A*; Procyon, *F*; Capella and the sun, *G*; Arcturus, *K*; Betelgeuse or Antares, *M*. Notwithstanding the very varied constituents represented in the atmospheres of these different types, astronomers have unanimously, and from various considerations into which I cannot enter, reached two conclusions, which are, indeed, generalizations of very fundamental importance.

The first is that all the heavenly bodies—nebulæ, stars, planets, and satellites—are of the same constitution, composed of the terrestrial elements, or, to be more precise, possibly in some cases of the substances from which the terrestrial elements have developed. Shortly stated, all are agreed on the fundamental unity of the cosmos. The second conclusion is that the marked differences in the spectra of different types are produced only, or at least mainly, by differences of temperature. From the distribution of spectral intensity in these various types (a rough indication being also given by their colors) the probable temperatures of the radiating atmospheres of the stars have been determined, ranging from about 3,000 deg. Cent. (5,400 deg. Fahr.) in the *M* stars to about 20,000 deg. Cent. (36,000 deg. Fahr.) in the *B* types. Our sun, of the *G* type, is at a temperature of about 5,000 deg. Cent. (9,000 deg. Fahr.). Furthermore, astronomers are generally agreed that the fundamental cause of the great differences in temperature indicated and the enormously high temperatures reached can be ascribed to the condensation, under the action of gravitational force, of the gases of which these bodies are composed. Starting with the primordial substance of gaseous or other character present in the nebulæ, whose particles attract one another, and hence, by the principle of the conservation of energy, producing heat and increasing the temperature, the process of this evolution has been traced in an orderly fashion through the various types, but in two different methods, resulting in two distinct theories on the order of stellar evolution. It will be of great interest, first of all, to sketch briefly the main features of these two theories, and then to adduce the latest evidence leading to the support of each. To do this will not only clarify our ideas about the constitution and development of the stars, but it will also lead (and this is the main object of this paper) to statements of the recent advances in our ideas, not only of the constitution, form, and structure of the universe, but of the ultimate constitution of matter.

The idea of the evolution of the stars most generally accepted by astronomers is that the nebulous material, whether gaseous or pulverulent, condenses under the self-attraction of its matter, rises in temperature, getting hotter and hotter, until it forms the *B* and *A* type stars of very high temperatures and low density—the early-type stars, as they are generally called—in which the principal elements showing in the outer atmospheres are the light gases, hydrogen and helium. The enormous radiation into space, combined with the slowing rate of condensation as the density increases, causes a gradual lowering of the temperature, the disappearance of the lines of helium, the appearance of more and more metallic lines, and the change of type through *F*, *G*, and *K* into the *M* type stars, where the banded appearance due to chemical compounds appears. These bands evidently can only appear when the temperature becomes sufficiently low to allow their formation. The fall of temperature is indicated further by the changing colors from blue and white to yellow, orange, and red. After the *M* type is reached, the fall of temperature is rapid, the loss of light even more rapid, and the star soon becomes invisible. The other idea of the evolution of the stars, which postulates stars and spectral types on both the ascending and descending scale of temperature, was primarily due to Sir Norman Lockyer, many years ago. A modified form of this hypothesis has been quite recently advanced by Russell, and vigorously supported by considerations adduced from the latest additions to our knowledge of the universe. Briefly, Russell believes in the same primordial matter, the condensation and rise of temperature, as before; but, he claims that as the nebula condenses and becomes hotter, we have visible stars formed first of the low-temperature red *M*-type stars. Increasing temperature causes these to pass through all the spectral types, *K*, *G*, *F*, to *A* and *B*. Afterward, they again pass through the same stages in the reverse order on the descending scale of temperature in exactly the same way as postulated by the other theory. Thus, all the stars pass through the yellow and red stages twice—once when the temperature is rising, and once when falling. In the former state, it is evident that the stars will be much less dense, and therefore of much greater diameter, and consequently brighter. Hence, if it can be shown that there are red-type stars both of less and greater density than the white stars, it will form a strong argument in favor of the theory.

Much can be said for and against each theory of stellar evolution, and it is not possible to tell which is nearer the truth. I will try and state briefly the case for each, and bring forward the most recent information in my knowledge in support. It has been generally believed that the order of evolution postulated in the first theory was the correct one, on account of the close analogy and similarity between the spectra of the gaseous nebulæ and the *B*-type stars. The nebulæ contain, besides the lines of hydrogen and helium present in the *B* stars, lines of an unknown element called nebulium. It is possible to trace an orderly development from the spectra of the gaseous nebulæ to the *B* stars through some intermediate types or sub-types of spectra called in the Harvard classification the *O* type, and also in a few very distant and faint stars called the Wolf-Rayet stars. The gaseous nebulæ give bright-line spectra, and we see the gradual fading out and replacing of the bright lines by absorption-lines in passing from the nebulæ through the *O* types and Wolf-Rayet stars to the *B* type, and the same progression in the number and character of the lines as occurs in the evolution from *B* and *A* to the yellow and red stars. So that we can trace, in a consecutive and apparently continuous course, the evolution from the nebulæ through the *O* to *B*, *A*, *F*, *G*, *K*, and *M* types, without any apparent gap left between the nebulæ and the *O* and *B* in which we could insert the red and yellow types, low-temperature, low-density stars required by the second hypothesis. This consideration has, moreover, been strengthened very materially by the work done within the last year or so by Nicholson, a mathematical physicist of the University of London. The physicists, as you know, within the last few years have been upsetting our ideas about the atom as being the ultimate division of matter—have been, indeed, introducing astronomical ideas into its constitution, the most recent idea—perhaps I would be safer in saying one of the most recent ideas—being that the atom is a sort of solar system, as it were, having as its central sun a nucleus of a positive charge of electricity, the planets being negative electrons revolving around it—the infinitely small and the infinitely great being here brought into close analogy. Three years ago Nicholson published a remarkable mathematical investigation on the spectra of

* President's Address at the Annual Meeting of the Royal Astronomical Society of Canada. From the Society's Proceedings.

the nebulæ, especially on the lines given by the hypothetical element nebulium, which has no known terrestrial analogue. By assuming the atom of nebulium to be composed of a positive charge, with four negative electrons revolving around it, he was able to show that the oscillations of this system, under ordinary dynamical laws, would give spectral lines in the position of the principal nebulium lines, thus indicating that the atom of nebulium is of a very simple structure. Three or four other papers along allied lines have been published by him within the last year which have a special bearing on our theories of evolution. Briefly speaking, he has built up a very striking and beautiful theory of the evolution of the elements, and illustrated and confirmed it by computing the wave-lengths of the principal lines in the nebulæ and early-type stars, and these computed values are in very close agreement with the observed positions.

Assuming the form of the primary atom to be a simple ring system with a nucleus of one positive charge +e and one negative electron, computation shows that the oscillations of this system will set up a vibration in the ether giving the wave-length λ1,823.55. This wave-length is almost exactly half of λ3,647.14, the observed wave-length of the limit of the principal Balmer series of hydrogen lines. This he calls proto-hydrogen, in analogy with Lockyer's nomenclature, and states that it must be presumed to be a constituent of nebulæ, although, owing to the absorption of our atmosphere, it can never be observed. The first evolution product of this atom is hydrogen. The simple ring atom with a nucleus of a positive charge of 2e and 2 electrons gives lines strongly present in nebulæ, which were also very strong in Nova Persei. The chief line is 3,868.88. The atom with nucleus +3e and 3 electrons gives lines present, though not so strongly in the nebulæ. The chief line is λ5,187. Nebulium is the simple ring atom with nucleus +4e and 4 electrons, giving among others the strongest nebular lines 5,006.89 and 4,363.5. The unknown lines in the Wolf-Rayet spectrum can be readily obtained from nebulium. Nicholson says that they are the leading members of a set of series analogous to Balmer's *H* series, but containing different constants, calculable from the properties of the atom of nebulium. The simple ring atom with nucleus +5e and 5 electrons gives the main lines in the solar corona, and Nicholson calls this proto-fluorine. The atom with nucleus +6e and 6 electrons gives the lines 3,484.7 and 3,111.4. The first coincides almost precisely with the strong ultra-violet radiation found by Max Wolf in the Wolf-Rayet stars, while the second cannot be observed. If this atom loses two of its electrons its vibrations will produce the lines λ3,729 and 4,068.8 so prominent in the nebular spectrum. The calculation of the atomic weights of these atoms, according to Nicholson, gives:

For atom of nucleus + 2 e = 0.3275
4 e = 1.31 nebulium
5 e = 2.05 proto-fluorine
6 e = 3.95 archonium

This has been corroborated by an experimental research of Fabry, Buisson, and Bourget, who showed that a substance giving the nebular line λ3,729 should have an atomic weight of nearly 3. Nicholson does not consider these simple ring systems as elements, but rather as origins from which elements may spring. He thinks that these atoms differ from the atoms of terrestrial substances principally in the nucleus, which in the latter consists not of a simple positive charge but of a complicated system of positive and negative charges packed together, and he regards matter in its nebular beginnings as being in a different state from its ultimate form in terrestrial elements.

These investigations show very clearly the analogy, mathematically computed, between the gaseous and planetary nebulæ and the Wolf-Rayet stars. This theory has been most strikingly corroborated experimentally by some recent work of Wright, published only within the past month in the last issue of the *Astrophysical Journal*. He has observed the spectra of the nucleus of the planetary nebulæ *N.G.C.* 6,572, and found it contains a number of the Wolf-Rayet lines. Conversely, observing the gaseous envelope, discovered by Campbell, surrounding the Wolf-Rayet star *B.D.* +30.3,639 degrees, and which the latter found was composed of hydrogen, Wright finds in addition to emission due to hydrogen, the lines of a planetary nebula, and concludes hence that the nuclei of planetary nebulæ are Wolf-Rayet stars. Some years ago Pickering announced that a series of lines of unknown origin discovered in the *O* type star Zeta Puppis, was probably another series of hydrogen similar to Balmer's series, though these lines had never been seen in the laboratory spectrum of hydrogen. About two years ago, Fowler, who had previously reproduced the spectra of comets in a vacuum-tube, obtained this series of lines and the line or band 4,686, also very prominent in early-type stars, in a tube containing helium with hydrogen impurity. Shortly afterward, Bohr, who has brought forward another very interesting theory of atomic structure, differing from Nicholson's, in considering the vibrations as being produced under laws different from those of ordinary dynamics, stated that this series and λ 4,686 were due to the helium atom postulated as having a nucleus of positive charge 2e and only one electron. The question between Nicholson and Bohr as to the constitution of the atom cannot be regarded as settled, although Nicholson appears to have the last word. There results, however, from these considerations, a very definite relation and connection between the spectra of the gaseous and planetary nebulæ, the Wolf-Rayet stars, the Novæ and the early-type stars of the groups *O* and *B*, which seems to be very well established, and forms a strong argument in favor of the first theory of stellar evolution—namely, that the *O* and *B* stars are the direct product of the condensation of the gaseous nebulæ without intermediate stages of red and yellow stars.

I cannot do better in presenting the case for the other theory of stellar evolution, which postulates stars on both ascending and descending temperature scales, than to follow Russell, not only the founder in the present form, but its able and persistent advocate. Russell follows the spectral nomenclature introduced at Harvard, and shows first of all by the differences in the color indices (the color index of any star being the difference between the visual and photographic magnitudes and evidently a function of the spectral type), how well the divisions in the spectral scale, though produced somewhat empirically at Harvard, have been placed. This is also indicated by the stellar temperatures corresponding to each division. He tabulates the available information in regard to the relation between the spectral classes of the stars and their color indices and temperatures, their numbers, their parallaxes, and their mean peculiar motions. These appear herewith:

Spect.	Color Index.			Temperature.	Counts.		Mean Parallax 5th mag. Boss.	Peculiar Motion.	
	King.	Parkhurst.	Schwarzschild.		Number above 6.25 mag.	— % in Galactic Region.		Campbell.	Boss
				Deg. Cent.			Sec.		
O	....	....	....	......	30	100	0.004	....	....
B	0.32	....	....	20,000	696	82	0.007	6.5	6.3
A	0.00	0.00	0.00	11,000	1,885	66	0.010	10.5	10.2
F	0.30	0.43	0.40	7,500	720	57	0.012	14.4	16.2
G	0.71	0.86	0.84	5,000	609	58	0.008	15.9	18.6
K	1.16	1.30	1.35	4,200	1,719	56	0.010	16.8	15.1
M	1.62	1.68	....	3,100	457	54	0.008	17.1	17.1
N	....	2.5	....	2,300	8	87	Kapteyn 0.000	....	....

Some of the figures do not afford any evidence in favor of the second theory, but rather on the contrary: if the age of a star has any influence on its velocity, then the peculiar motions show that the *B* and *A* stars are of the earliest types. At the same time, the recent work at Lick on the radial velocities of the planetary nebulæ, which are in the mean greater than 40 kilometers per second, seems to be decidedly against the theory that the *O* and *B* stars, whose velocities are small, have developed directly from the planetary nebulæ. However, Russell lays the greatest stress on the relation between the spectral type and the absolute brightness or magnitude of the stars, which had previously been discussed by Kapteyn, Herzsprung, and others. It is evident that stars can only be compared for absolute or intrinsic brightness when their distance is known; and, unfortunately, owing to the very great distance of most of the stars, only comparatively few have had their parallax or distance measured with reasonable accuracy. Kapteyn defines the absolute magnitude of a star as the magnitude it would have if placed at a distance whose parallax was 0.1 second, equivalent to 32.6 light-years. At this distance, another name being 10 parsecs (10 times the distance for a parallax of 1 second), our sun would appear as a star of about 4.7 magnitude, this being hence its absolute magnitude. Russell has compiled the fairly reliable direct measures of parallax, about 300 in number, and those which can be determined from their positions in moving clusters, about 150 in number, a total of about 450 stars. From these parallaxes, the absolute magnitudes are readily derived when the observed magnitudes are known. These have been plotted graphically in relation to the spectral types, and some very remarkable results obtained. The total range of absolute luminosity or brightness of the stars is enormous, as they range from stars about 3,000 times as bright as the sun to those only about 1-3,000th as bright.

The results obtained from a study of these graphs may be stated as follows: In the first place, all the white stars, those of *B* and *A* types, are bright, of the order of about 100 times the sun's brightness. Second, all the very faint stars whose brightness is less than one fiftieth that of the sun are red stars of types *K* and *M*. Third, the absolute brightness of the spectral classes decreases as we proceed from *B* to *M*, from white to red stars, those of the same type (*G*) as the sun being of about the same brightness. Fourth, besides this gradual decrease in brightness, there are a number of stars in each spectral class very bright, averaging about 100 times the brightness of the sun. Examples are the red stars Aldebaran, Arcturus, Antares—the latter 2,000 times as bright as the sun. Fifth, there is a certain limit of brightness for each spectral class, below which stars of this class are very rare; each class varies over a range of about two magnitudes, and each class is about seven times brighter than the next redder class. Sixth, in the red stars of *K* and *M* types, there are no stars of the same brightness as the sun, though there are many much brighter and many much fainter. We may express this in another form by saying that there are two great classes of stars—the one of great brightness, averaging about 100 times the sun, and varying little from one class of spectrum to the other; the other of less brightness, which falls off very rapidly, with increasing redness. These two classes were first noticed by Herzsprung, who called them very fittingly, "giant" and "dwarf" stars. The question naturally arises, What differences in nature, constitution, or development, give rise to the differences in brightness between the giant and dwarf stars, and why should these differences become more marked as the stars become redder? We must not forget that we are now discussing the absolute magnitudes, the actual luminosities, of the stars, their apparent brightness, if all were placed at the same distance from us. It is evident that this must depend on the three factors—the mass, the density and the surface brightness. Large mass, small density (which, of course, gives large volume and surface area), and high surface brightness go to produce giant stars, which will appear when one or more of these attributes are present, while the dwarfs occur when the opposite attributes preponderate. What information has been collected as to the masses, densities, and surface brightnesses of the stars? For this we are mostly indebted to data obtained from visual and spectroscopic binaries for the masses, from eclipsing variables for the densities, and to spectro-photometric investigations for the relative surface brightness of the different spectral classes. From these data, we find that, although we have a known range in the absolute magnitude of a million-fold, and in the densities of about the same amount, the range in masses, so far as known, does not exceed fifty-fold. At the same time, there is some evidence of a relation between mass and luminosity. For example, those stars known to be of small mass are in general fainter than the sun, while the stars of class *B*, which are all very bright, are, on the average, of ten times greater mass than the sun. The study by Russell of eighty-seven eclipsing variables led to some very striking and interesting results in regard to the densities of these stars, which may be taken, probably without serious error, as typical of the densities of the stars generally. The stars of classes *B* and *A* are approximately similar in density, ranging from about one third to one forty-fifth of the sun's density. On the other hand, the densities of stars of the classes *G* and *K* vary enormously, ranging from *W* Ursæ Majoris (nearly twice as dense as the sun) to *W* Crucis (about one-millionth the sun). We have here, then, the explanation of the enormously different brightness of the giant and dwarf stars of classes *K* and *M*. We know that the surface brightnesses are approximately the same, and that the masses are of the same order; hence, the difference must lie in the densities, and this we have seen is possible from the examples above. If we take the typical giant star of class *M*, which averages about 1,000 times as bright as the dwarf of the same class, and assume the mass and surface brightness the same, the giant will be only one thirty-thousandth as dense as the dwarf.

(*To be concluded.*)

A Discovery of Molybdenite is reported at the head of Lost Creek, near Salmo, in the Nelson mining division of British Columbia. The deposit appears to be of considerable size and two carloads have already been mined. Concentration will be necessary to bring it up to 85 per cent molybdenite.

The Gun and the Aeroplane

The Difficulties and Principles of Aiming

THE conspicuous want of success of the gun in its encounter with the aeroplane since the beginning of the war has been summed up in the remark that any attempt to cripple an aeroplane with a rifle may be compared to killing a mosquito with a pea-shooter at a distance of a hundred yards—a manifestly impossible feat. The difficulty is undoubtedly very great, though perhaps not quite so great as this remark implies, and the purpose of this article is to point out some practical ways in which it may be overcome, or at least much reduced, the suggestions advanced being based upon shooting eagles and condors at considerable heights. It is true that rifle fire at aeroplanes is forbidden to private citizens, but the principles on which it should be based are nevertheless of interest.

A good rifle, as we know it to-day, is, roughly speaking, point blank up to 500 yards. It has a long range and a low trajectory. If it were fired point blank at a target 1,000 yards away the bullet would strike the ground at the foot of the target. That is to say it would be deflected from its course some 5 feet. What deflects it? The weight of the bullet. Its weight acts at right angles to the course of its flight, and thus exerts its maximum influence upon the bullet to deflect it from its initial course. At 1,500 yards the deflection would be nearly double that at 1,000 yards, and at 2,000 yards it would be a good deal more, let us say 28 feet. Hence when firing under usual rifle-range conditions at a mark 2,000 yards away it is necessary to aim 28 feet above it. These adjustments are made by raising and lowering the back sight, which is movable and graduated more or less exactly to suit certain fixed distances.

Now let us suppose the target is moved to a point 2,000 yards vertically over the rifleman's head, and that obedient to his usual custom when shooting at such distance he fixes his back sight on the 2,000-yards mark. If his aim be true he will miss the mark by exactly 28 feet. Why? Because his bullet has not been deflected from its initial course, for the reason that its weight does not now act at right angles to, but in the direct line of, its course. There is therefore no force acting on the bullet that would tend to turn it from its course in any particular direction. It would go straight up and straight down if there were no wind to affect it.

In passing from the horizontal to the vertical the target has passed through an indefinite number of intermediate positions, and in shooting at every one of

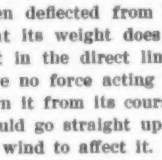


Fig. 1.

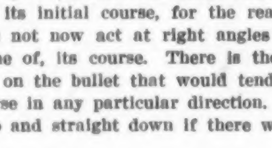
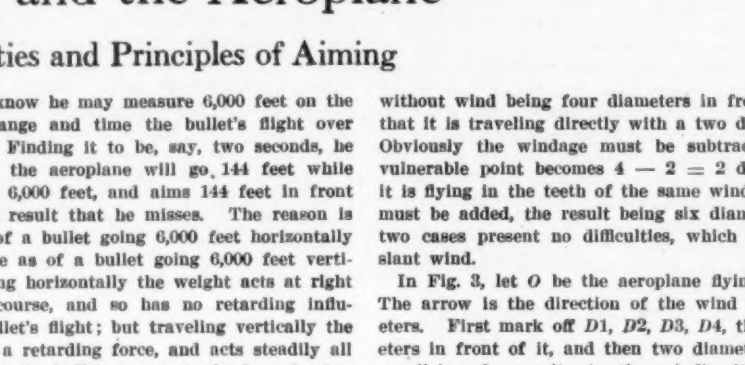


Fig. 2.

these positions the weight of the bullet acts with a different power. When the angle of fire is at 60 degrees with the horizontal, that is, two-thirds of the way up, the power of the bullet's weight to alter its course is just half what it is when the direction is horizontal. Thus, in Fig. 1, if the rifle is at A, Z is the zenith, $A\ H$ is the horizon, O the position of the aeroplane, and $O\ A\ H$ an angle of 60 degrees, then $A\ O\ H$ is an equilateral triangle, $A\ P$ is the horizontal distance of O, and $A\ O$ the actual distance of 2,000 yards. $A\ P$ is half $A\ O$; therefore the aeroplane's horizontal distance is 1,000 yards, and the marksman would be right, when shooting at this angle, to sight his rifle at exactly half the actual distance. This is a particular case. The general position is given by the formula—horizontal distance = actual distance × the cosine of the angle of inclination.

Now move O a little farther on, keeping $O\ P$ vertical all the time. Soon $A\ P$ will be 500 yards in length. That is to say, the horizontal distance of the aeroplane is 500 yards, or in other words point blank. That is the place to begin to fire at it. While it is passing from O through Z to O_1, a distance horizontally of 1,000 yards, it is all the time within point-blank range of the rifle, because the distances $A\ P$ and $A\ P_1$, are both 500 yards.

So far the aeroplane has been considered as a stationary object in the sky, but its rapid movement must now be taken into account. Suppose that it is traveling at 50 miles an hour, or 72 feet a second, and flying at a height of 6,000 feet, how many seconds will it take the bullet to go 6,000 feet? If the marksman does not know he may measure 6,000 feet on the nearest rifle range and time the bullet's flight over this distance. Finding it to be, say, two seconds, he calculates that the aeroplane will go 144 feet while the bullet goes 6,000 feet, and aims 144 feet in front of it, with the result that he misses. The reason is that the time of a bullet going 6,000 feet horizontally is not the same as of a bullet going 6,000 feet vertically. Traveling horizontally the weight acts at right angles to its course, and so has no retarding influence on the bullet's flight; but traveling vertically the weight acts as a retarding force, and acts steadily all the time, so that the bullet goes more slowly and takes



A German anti-airship gun.

longer to get to the aeroplane than two seconds. How much longer? That depends on the rifle and the bullet, but suppose it to be one second longer, or three seconds altogether. In that time the areoplane has gone 3 × 72 feet = 216 feet; hence a shot aimed at a point 216 feet in front of the aeroplane should reach its mark.

To judge a distance of 216 feet, or any other distance, in front of the machine is very difficult, but help may be obtained from experience with shooting eagles. The spread of the eagle's wings being, say, 5 feet, if the rifleman wants to fire 15 feet in front of the flying bird he must judge three times the wing spread or three "diameters," as is quite easy to do with a little practice. If the diameter of the aeroplane be taken at 50 feet, then to judge 216 feet he must mark off four diameters in front of the machine (neglecting the extra 16 feet); and to mark off four diameters or even ten diameters on the face of heaven is much easier than to try to guess where 216 feet comes to. Thus for a machine traveling at 50 miles an hour at a distance overhead of 6,000 feet, the shot must be aimed at a point four diameters in front of it. Other rates of speed and other distances will give other results in terms of diameters, all quite simply obtainable, and these results may be conveniently summarized and tabulated as a sort of ready reckoner.

So far no account has been taken of wind, which is the most difficult factor to deal with. There are no rules applicable to its waywardness, and only careful

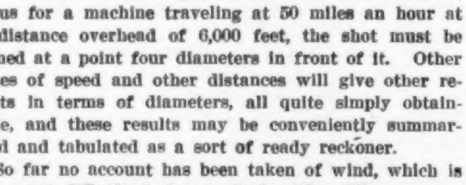


Fig. 3.

study and experience can enable a rifleman to form correct estimates of its power. When, however, a rifleman has made up his mind how strong the wind is he must express its strength in terms of diameters, just as in the case of the distance and the speed. The effect of wind on a bullet is far more marked in vertical shooting than it is in horizontal, for usually the greater the height, the stronger is the wind. It may be suggested, subject to correction in the light of experience, that a wind for which 25 feet would be allowed at 6,000 feet on a rifle range should be given three times that amount in vertical firing at the same distance, that is, 75 feet.

Suppose that the aeroplane is still flying at 6,000 feet, and at 50 miles an hour, its vulnerable point without wind being four diameters in front of it, and that it is traveling directly with a two diameter wind. Obviously the windage must be subtracted, and the vulnerable point becomes 4 — 2 = 2 diameters. If it is flying in the teeth of the same wind the windage must be added, the result being six diameters. These two cases present no difficulties, which begin with a slant wind.

In Fig. 3, let O be the aeroplane flying towards L. The arrow is the direction of the wind of two diameters. First mark off $D1$, $D2$, $D3$, $D4$, the four diameters in front of it, and then two diameters from $D4$, parallel and opposite to the wind's direction. The point $D6$ is the place to aim at, the extremity of the diagonal of the parallelogram formed by the speed of the machine on the one side and the force of the wind on the other, both expressed in diameters.

It certainly seems difficult to ascertain the position of this diagonal and of its end, but the aeroplane itself supplies a helpful hint. In Fig. 3 the aeroplane is drawn as though its axis were in the same straight line as the direction of its flight to L, as would unquestionably be the case if the wind were directly behind it or directly in front of it. In a cross wind the situation is different, more as represented in Fig. 4. In a strong cross wind it is not possible for a machine to keep its axis in a direct line with its line of flight. The line of axis is brought round so that it

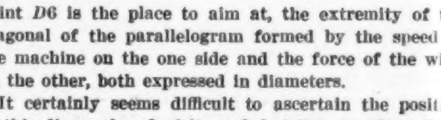


Fig. 4.

lies at an angle with the line of flight, with the head of the machine turned slightly towards the direction of the wind. The new line of axis corresponds roughly with the diagonal of the parallelogram we are engaged in finding.

With reference to the actual position and attitude of the marksman when he makes his shot, the experience supplied by the eagle is again useful. When a rifleman sees a bird (or an aeroplane) coming directly towards him overhead he naturally gets a shot at it as it approaches the zenith. In doing so he closes his left eye and draws a bead on the mark, and then moves his rifle slowly along the line of flight in advance of the moving object to find the vulnerable point. But directly his rifle leaves the eagle to gain the desired point in front of it, the object is shut out of sight by the barrel. He cannot, therefore, measure correctly his number of diameters in front of it, for the unit of measurement is obscured, and he has to make a hasty and approximate guess. That is why the first shot is usually a failure. The more favorable way is for him to turn his back to the oncoming object, lean back as far as he can until it comes into his field of vision; this is easier if he is sitting or able to lean his back against a fence or rock. In this way he can get a line on the required point without obscuring the object and can measure his diameters with all the exactness in his power. Thus his first shot is on its way before the object has reached the zenith and he can empty his magazine before it is out of point-blank range without having to turn round and destroy his foothold and balance.—BLAMIRE YOUNG in Engineering Supplement of *London Times*.

The Utilization of Exhaust Steam*

Various Ingenious Systems for Promoting Economy of Fuel

Exhaust steam from a non-condensing engine contains 90 per cent of the energy which it possessed when it entered the cylinder. Some of this waste energy can be utilized, either for heating, or for driving a low-pressure turbine engine. The first method is employed in breweries, sugar houses, paper mills and chemical factories, where large quantities of low-pressure steam are required for heating, evaporating and drying. The second method is used in mining and metallurgical industries, where power is more needed than heat.

An arrangement of this sort is illustrated in Fig. 1. The exhaust steam, ejected intermittently from the cylinder at little more than atmospheric pressure, enters a collector large enough to equalize its pressure and allow it to flow in a steady stream to the turbine whence, after doing its work, it passes to the condenser. The low pressure of the exhaust steam requires a high vacuum in the condenser and necessitates the employment of a turbine, which works far more efficiently than a cylinder engine in these conditions.

The economy effected appears from the following considerations. Of 100 parts of potential energy in the fuel, 6 are lost by radiation and conduction from a good furnace and boiler, 15.5 in heating the chimney gas, 1.5 in the hot ashes, and 3 in the form of gases escaping unburnt, but 5 parts may be saved by feeding the boiler from the turbine condenser, and 8 by employing the chimney gas to heat the feed water. Hence, 87 parts reach the non-condensing cylinder engine which, with an efficiency of 10 per cent, converts 8.7 parts into work, while the more efficient turbine extracts an equal amount of work, 8.7 parts, from the exhaust steam.

The result necessarily varies according to local conditions, but the example cited illustrates the possibility of doubling the power of a non-condensing engine by driving a turbine with the exhaust steam.

This method is employed most profitably with hoisting engines, steam hammers, etc., which work intermittently and would be little, if at all, improved by the addition of a condenser alone. In view of the high cost of the turbine, with its collector and condenser, it is best to make one such installation serve several non-condensing engines, if possible. Good condensing cylinder engines work so efficiently that the saving effected by the addition of a turbine does not pay for the cost of installation.

The arrangement shown in Fig. 1 is suitable only in connection with a reliable and nearly uniform supply of exhaust steam, which is not always furnished by intermittently working engines. The steam collector equalizes the pressure and flow for short intervals, but if the cylinder engine is idle for longer periods the simple low-pressure turbine must be replaced by a high and low-pressure turbine, taking steam directly from the boiler, if necessary.

This combination is illustrated in Fig. 2. The admission of steam to the turbine is regulated automatically, so that the supply to the high-pressure wheel is cut off, and the machine is operated as a simple low-pressure turbine, when the supply of exhaust steam is sufficient, while at other times a greater or smaller quantity of boiler steam is admitted to the high-pressure wheel, and the machine is operated as a compound turbine.

In a Rateau turbine constructed for this use by the Augsburg-Nuremberg Company, the valves of the steam pipes are operated by two regulators, controlled, respectively, by the pressure of the exhaust steam and the speed of the turbine. By this device the power furnished by the turbine is made constant and independent of the supply of exhaust steam.

The savings effected by the simple and compound turbines are approximately equal, as the boiler steam admitted to the compound turbine produces its quota of additional work. At all events, the employment of a compound turbine for the utilization of a fluctuating supply of exhaust steam is preferable to the older practice of using a low-pressure turbine and admitting boiler steam to the collector, through a throttle valve controlled by the pressure in the collector.

The older methods of employing exhaust steam for heating likewise had the defect that the supply of exhaust steam did not always correspond with the demand for heat. In modern practice the steam for heating is taken, if possible, from between the high and low-pressure cylinders of a compound engine (Fig. 3), or the high and low-pressure rotors of a compound turbine (Fig. 4), the part of the steam that is not thus drawn off passing on through the low-pressure cylinder or wheel to the condenser. The quantity of steam taken is automatically adjusted to the demand for heat, without affecting the operation of the engine, the admission of boiler steam to the high-pressure part being regulated so that the power delivered by this part increases as the power delivered by the low-pressure part diminishes, and conversely. There is also a provision for the automatic admission of boiler steam directly to the heating apparatus, when sufficient steam is not furnished by the engine. Tandem cylinder engines accommodate themselves much better than twin-cylinder or triple-expansion engines to this varying distribution of power between the high-pressure and low-pressure parts, but in general the system works best with turbines. If steam of two different pressures is required for heating, the high-pressure steam may be obtained in this way, while the low-pressure steam is taken from the exhaust of the low-pressure cylinder or turbine.

With a 250-kilowatt compound cylinder engine, supplied with steam at 300 deg. Cent. and 11.5 atmospheres, and an hourly consumption of 2,000 kilogrammes of heating steam at 110 deg. Cent. and 1.5 atmospheres, the saving effected by heating with "intermediate" engine steam, instead of with steam from a separate low-pressure boiler, is about 40 per cent of the heat used for heating, or 20 per cent of the heat used for heating and power combined. The cost of the separate boiler is saved also.

Exhaust steam is more important as a source of heat than as a source of power for sugar, paper and potash factories, dye works, laundries, breweries, and all chemical and textile industries require steam in large quantities for heating and drying. In many cases where more steam is required for heating than for power, it may be found profitable to install the above described system and sell the excess of power in the electrical form. In other cases an excess of heating steam may be sold to neighboring establishments.

When the demands of the factory for heat and power are approximately equal and nearly constant, all of the exhaust steam of cylinder or turbine engine may be admitted to the heating apparatus at a definite "back pressure" (Fig. 5). Finally, the heating steam may be drawn from one end of the cylinder of a simple engine, while the other end exhausts into a condenser (Fig. 6). In this case it is possible to arrange the connections and valves so that both ends exhaust into the heating apparatus, or into the condenser, if all, or none, of the exhaust steam is required for heating.

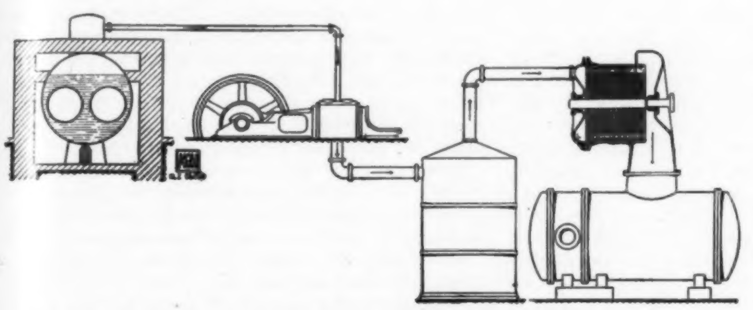


Fig. 1.—A low-pressure turbine driven by exhaust steam from a non-condensing engine.

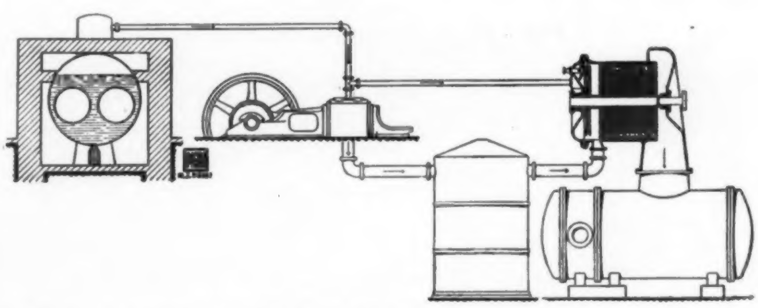


Fig. 2.—A compound turbine driven by boiler steam and exhaust steam from a non-condensing engine.

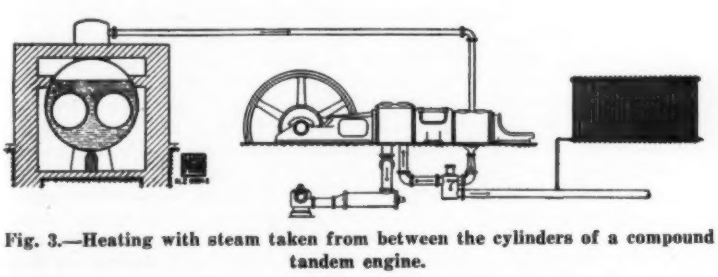


Fig. 3.—Heating with steam taken from between the cylinders of a compound tandem engine.

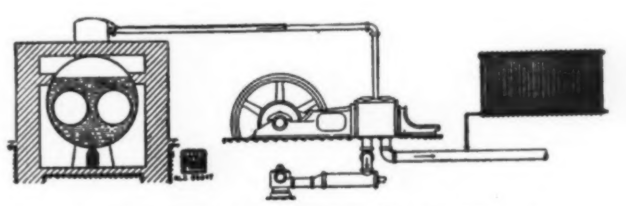


Fig. 6.—Heating with steam from one end of a non-condensing engine.

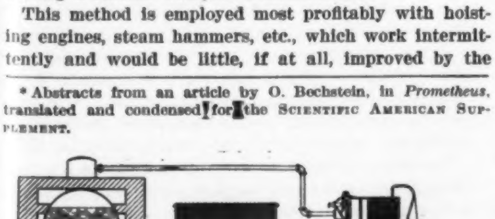


Fig. 4.—Heating with steam taken from between the rotors of a compound turbine.

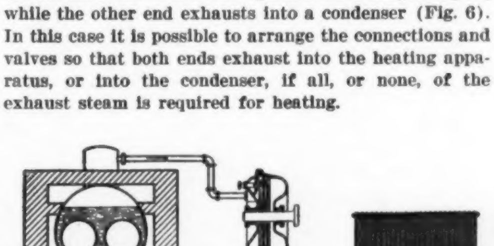


Fig. 5.—Heating with back pressure steam.

* Abstracts from an article by O. Bechstein, in *Prometheus*, translated and condensed for the Scientific American Supplement.

Electricity in Agriculture—II*

Advantages That Make It a Necessity on a Modern Farm

By Carl J. Rohrer, Agricultural Specialist of the General Electric Company

Concluded from Scientific American Supplement No. 2077, Page 266, October 23, 1915

Perhaps the most important of the applications of electric drive is that of pumping water for both domestic and general farm purposes. An electrically driven pumping equipment makes an ideal water system. In many instances it is necessary that the pump be situated a considerable distance from the buildings. In such cases the starting equipment can be installed at this central point and the motor, even though a half mile away, may be started and stopped at will, or it can be made to operate automatically. A motor-driven water system is not expensive to operate and the first cost is no greater than a similar installation using some other source of power.

With the ever-increasing population in our country, the land has become well occupied, and it is becoming almost a necessity that a system of water supply be secured which is independent of the running streams, due to the fact that the water of such streams may easily carry a contagious disease to the farm animals, causing a very serious property loss.

Hog cholera and foot and mouth disease are two of the most serious diseases at the present time which can be easily transmitted in this manner. Much of the loss from infectious diseases among farm animals has been directly traced to the running stream and the farmer may easily pay the cost of an installation of an adequate water system from the loss which he would suffer by the spread of disease among his herds. This danger has resulted in a very material increase in the number of such plants installed.

The cream separator at the present time has come into almost universal use, and when power-driven the saving in labor is quite appreciable. For instance, it has been found that an electrically driven separator of 500 pounds capacity per hour, even if only 200 pounds of milk is separated each day, will show a saving of $10 per year after all expenses are considered. In addition, there will be an actual saving in labor of at least 24 minutes per day or over two weeks' time during the year. This 24 minutes per day can be used to advantage in doing other chores, such as washing the milk pails, etc., thus lessening the chore period by that amount. A farmer separating 500 pounds of milk per day would save in actual cash $35 a year, this amount being left as profit after depreciation, interest, labor, and power are charged against the operation. There will also be available for other work during each day a period of one hour or thirty-six working days of ten hours each, which is a very considerable item to the average farmer.

One of the principal advantages tending to promote the use of the electric motor is its simplicity. No other source of power can compare with it in this respect. The horse must be fed and cared for, the gas engine must be adjusted, the steam engine requires a licensed engineer, but the motor needs only an occasional oiling.

Portability is another feature of the motor, it weighing only two sevenths as much as a gas engine of the same capacity. A 5 horse-power motor will weigh 340 pounds and can be easily transported from one building to another. This is of sufficient size to operate small feed grinders, corn shellers, fanning mills, grain elevators, concrete mixers, alfalfa mills, grain graders, hay cutters, etc.

When the central stations first tried the installation of portable equipments, it was difficult, if not impossible, for the farmer to change the motor from one point of use to another. This meant that a representative of the central station must make a trip to disconnect and reconnect the motor to the lines. However, a few simple instructions have been found sufficient to eliminate this inconvenience, and ordinarily motors are now changed from one place to another without difficulty. Several hundred feet of armored cable are usually kept ready, this being used in case it is necessary to install the motor some distance from the nearest outlet box.

It is really remarkable the number of things which can be accomplished with one or two motors about the average farm. On rainy days they are used to grind feed clean and grade grain, shell corn, etc., and at other times to operate concrete mixers, grain elevators, wood saws, etc.

Actual experience has demonstrated that a farm of average size requires about four motors, as follows: a ⅛ or ¼ horse-power for the house, a 1 horse-power motor for the small farm machines, a 5 horse-power for machines of intermediate size, and a 15 or 20 horse-power motor for the heavier farm machinery.

In the past the tendency has been to have the threshing, corn shelling, baling and ensilage cutting done by a custom machine, i. e., a machine owned and operated by a crew of men separate and distinct from the farmer's own organization. Indications point to the fact that this system is rapidly going out of use, the general tendency at the present time being for the farmer to buy a small equipment and operate it with his own help. For instance, in the past a threshing equipment consisted of a grain separator with a 32- or 36-inch cylinder, necessitating a large traction engine and a very considerable force of men to keep the outfit in constant operation.

The president of one of the large threshing machine manufacturing companies made a statement not long ago to the effect that the demand is rapidly shifting toward the smaller machines. The reason for this is attributed to the fact that the farmer can do his own threshing with the assistance of but two or three neighbors, whereas with the old system it required the combination of from ten to twenty farmers and from twenty-five to thirty-five men to keep the machine in motion. The result was that one or two weeks' time was required to complete the threshing. If any breakage occurred, it meant the loss of at least a half day for the whole force. Another disadvantage, especially during a rainy summer, was that someone had to have his threshing done last and would in all probability suffer a considerable loss, due to the damage from the weather.

With the new arrangement, the work can go on without the loss occasioned by the old system, and, in addition, any postponement of the work does not necessitate the replanning of work of the whole neighborhood. The points mentioned also hold true for ensilage cutters, hay balers and clover hullers; however, the force of men required in this case is not so large as in the previous illustration. This change also means a larger market for small-sized equipments of all kinds and, furthermore, it means that one or two farmers will now combine and purchase a portable motor and transformer of sufficient capacity to operate these machines. This was impossible before, because the large equipments required from 75 to 100 horse-power to operate them; now 35 horse-power is usually the maximum needed.

A 15 or 20 or even a 35 horse-power motor can be easily transported together with a suitable transformer from one farm to another. Formerly it was necessary for a representative of the central station to disconnect and reconnect the transformer whenever such a change was made; at present, however, an armored cable is used having at one end suitable leads equipped with hooks. These hooks can be hung over the transmission wires or removed with perfect safety by the farmer.

In some cases a flat charge of from $5 to $10 a day is made for the electricity, but usually a meter is installed on the secondary side of the transformer, the current used being paid for at the regular rates. Such an outfit is very flexible, as it eliminates the core loss of the transformer when not in use, and, in addition, gives the central station a very good summer day load.

Instead of using horses to draw the hay into the mow the farmer now uses a power hay hoist. This is readily adaptable to electric drive, the motor being belted to the hoist. With these hoists all operations are controlled from the load and, of course, this can be readily accomplished in the case of motor drive.

In the potato-growing regions of the United States motor-driven potato sorters have come into considerable use. Motors are also of value in the apple industry for driving belt conveyors and apple wipers.

The newspapers and magazines have perhaps published more articles describing the remarkable results obtained by stimulating plants electrically than any other one farm subject. However, the facts of the case are that the whole matter is still in the experimental stage, and while results have been obtained they have not been conclusive, and, furthermore, their value from a practical standpoint is still very much in doubt. The United States Government has been investigating this subject and finds that, while the plants show beneficial effects, these are not sufficient to warrant the use of this application on a commercial scale.

This lack of results may be due to the fact that the action of the electric current on the metabolism of the plant is not fully understood, and it may be that further investigation will bring out important discoveries which will make such applications practicable; however, at the present time nothing of commercial value has been developed.

Another innovation in the way of electric drive has been its application to compressed air spraying equipments for the protection of orchards and truck gardens from the injurious ravages of insects and beetles. The outfit consists of a motor-driven air compressor which supplies air at a pressure of some 200 or 300 pounds per square inch. All equipments, including the mixing tanks, are located at a central point. The spraying carts are equipped with two tanks, one for the spray liquid and the other for the compressed air.

The two tanks are interconnected at the bottom through a pipe containing a reducing valve, thus giving a constant pressure in the liquid tank of 100 pounds per square inch, which is the best pressure to use for spraying purposes. The compressed air entering at the bottom of the liquid tank also serves to keep the spraying liquid agitated and prevents the solid constituents from settling to the bottom.

This equipment, while costing a little more, weighs less and requires practically no mechanical skill. The man at the mixing station can mix the liquids, the motor operating automatically when air is needed.

The farm shop is not complete without electrical equipment, a small motor being very convenient to drive small saws, grindstones, emery wheels, and forge blowers. An electric portable drill is quite popular, as it enables repairs to be made on machinery in other buildings without tearing the machine down and taking the part to the repair shop. The electric soldering iron is another handy device, as its convenience in attaching to any lamp socket makes it available for use wherever there is electric current.

Electric hot water heaters find many applications about the farm, especially in cases of sickness among the farm animals, as they make a supply of hot water available in all the farm buildings. In several instances they have been used as paint buckets to keep paint warm while painting buildings.

These, however, are not the only applications of electricity, for the electric vehicle must be considered. At the present time there is a great deal of agitation tending toward the installation of hard roads throughout the various States. In the East remarkable progress has already been made in this direction. With the advent of these hard roads, the use of the electric vehicle will be appreciably increased. A number are already being used in the East for the marketing of farm products. Due to its simplicity and reliability, it is safe and unexcelled as a convenient method of transportation for the farmer's wife, for it enables her to do the family marketing and attend to her social duties in a manner never before possible. For this reason it will ultimately be the principal means of transportation for the feminine members of the farmer's household.

A review of the applications of electricity to agriculture would not be complete without a few words concerning a gasoline-electric harvester manufactured and used in California. This machine cuts, threshes and recleans the grain in the field all in one operation. The outfit consists of an 80 horse-power six-cylinder gasoline tractor and a combined harvester cutting a swath 35 feet wide and having a capacity of 2,200 bushels of grain per day. Upon the tractor is mounted a 20-kilowatt generator driven by the tractor engine. A 25 horse-power motor operates the moving parts of the harvester, such as the cylinder, sickle, conveyors, recleaners, etc.

The principal advantage of this equipment lies in its efficiency over the old method of driving by power derived through traction.

Other advantages are flexibility, light weight and lower operating cost. The cost per acre with this machine averages 80 cents against $2.50 for a horse-drawn harvester and $3 per acre where a stationary thresher is used.

Some idea of the possibilities of rural development may be gained from data obtained by a number of farm papers by means of circular letters addressed to their subscribers, who total some 400,000. The following figures give the approximate percentage of subscribers

* Courtesy *The General Electric Review*.

using the various types of machines to which electric motors can be applied:

64 per cent have washing machines.
15 per cent of these machines are power-driven.
96 per cent have sewing machines.
65 per cent have cream separators.
80 per cent have pumps.
6.2 per cent have water systems with power pumps.
33 per cent have incubators.
1⅔ per cent have milking machines.
12 per cent are now prospective customers for such machines.
60 per cent have fanning mills.
20 per cent have silos.
3.3 per cent have ensilage cutters.
9.5 per cent have threshing machines.
45 per cent have gas engines.
10 per cent have steam tractors.
20 per cent have feed grinders.
5 per cent have hay balers.

The above figures are from investigations made in 1913, and there is every reason to believe that all percentages have been increased by purchases during the last year and a half.

For instance, these investigations show that over 50 per cent of the farmers were planning to buy and install water systems requiring a power pump. As the number of farmers having power-driven machinery increases, the field for electric motors and for electric power will also increase in proportion.

Many of the central station companies throughout the United States have taken considerable interest in the farmer as a prospective customer, and a large amount of experimentation is now under way in order to determine what revenue may be expected from such installations and the most satisfactory method of financing them.

This is not a surprising fact when one stops to reflect that only a comparatively few years ago considerable doubt existed in the minds of electrical engineers and central station managers as to whether or not the residential lighting customer was a profitable proposition.

The same thing was true of the various applications of power. However, most of the difficulties of city distribution have reached a satisfactory solution, and to-day it is generally agreed that city lighting and power is very desirable business. The same difficulties are now being considered in the distribution of electric current to the farms and rural communities.

It should be also remembered that the problem of rural service requires special treatment and should, therefore, be considered as a separate and distinct branch of the central station industry.

Progress, however, will not be extremely rapid, due to the large number of questions which yet remain to be settled by experimentation.

As an isolated illustration, a central station company in the Middle West proposes to cover the county in which it is situated with a network of transmission lines. The county has an area of about 400 square miles and a population of 27,000 or 67 persons per square mile, the largest town having 5,000 inhabitants. This county has a rural population of 13,500, this figure excluding all towns of over 100 inhabitants. This means a rural population of 33.5 persons per square mile. At the present time only a small area of this county is being supplied with electric current; however, extensions are rapidly being made, and the ultimate plan is to completely cover the whole territory with transmission lines. There are some ten other small villages scattered throughout the country, the largest of which has a population of 1,900, with eight or nine others having a population of approximately 500 to 700. As the revenue from such small towns is comparatively small, the principal returns will have to ultimately be derived from the rural inhabitants.

The president of this company is also a contractor of very considerable importance in his own State and he feels convinced that his company can gradually make the necessary extensions and that they will pay a reasonable profit on the investment.

The prominence of this man in the business world is such that the result of his endeavors in this line will have considerable weight with a number of other central stations, who are awaiting results before venturing into the business on such an extended scale.

From the preceding figures, coupled with the fact that the United States has only about one sixth of the population per square mile that is found in Europe, it can easily be seen that the rural electrification in this country is really in its infancy.

A number of companies, however, have already conducted extensive educational campaigns, the most prominent of these being the Pacific Gas and Electric Company, the Edison Electric Illuminating Company of Boston, and the Pacific Power and Light Company. All have made exhibits showing the various applications of electric light and power to the farm. While the immediate results obtained have not been especially encouraging, the officers of these companies are convinced that this educational work will ultimately result in a large amount of new business.

Ordinarily, from a central station standpoint, farm lighting alone is not profitable, as power applications are the deciding factor which swings the balance from loss to profit. The average city customer installs the necessary number of lights, buys a flatiron and a few other devices, and the limit in revenue from this source has been reached. The farmer, on the other hand, keeps finding new things to do with electricity, and the farm load, even though the number of customers remains constant, increases each year through the addition of motors and various other devices.

The power situation is one which the isolated plant cannot economically meet except where water is available, or under such special conditions as the presence of cheap natural gas. Until such time as central station power can be made available, the gas engine must be the farmer's only alternative.

The principal problems for the central station are those of rates and first cost. Various systems are now being tried out throughout the country with varying degrees of success. Some companies build their own lines and consequently must charge a high rate, which will be unsatisfactory from the farmer's point of view, as it practically limits him to the use of electricity for lighting and absolutely discourages the use of power.

Other companies make the farmers build all the supply lines, furnishing power and light at a nominal rate, the lines remaining in the customer's possession. Others follow the same principle, but refund a certain percentage each year in electric current. Then if the line is a paying proposition this refund continues until the title of the lines ultimately comes into the possession of the central station.

Still other companies require at least four customers per mile with a guarantee of a certain monthly minimum. In addition, a connection charge is made which covers the cost of the poles and their erection, and sometimes even the transformer is added to the charge where lines are especially costly.

A variation of this consists of a connection charge with an alternative clause allowing the farmers to haul and erect the poles under the supervision of a competent foreman. This latter method has been found to be very satisfactory, as the farmer counts his time as a very small item and, in the majority of cases, he is more than willing to do this work because it enables him to get electric service without a large outlay of actual cash.

Sometimes the customer gets a refund in current running over a series of years or else all current consumed over a certain amount goes to apply on the refund. A service charge, as a rule, has been found to be unsatisfactory and should be avoided whenever possible.

By far the larger percentage of central stations who have been assisted by the farmers in erecting their lines are more than pleased with their farm business, and this method is becoming more and more the accepted practice among central stations. For it very materially reduces the first cost of such extensions and, in addition, gives both the farmer and the central station time to develop the consumption of electric current to such an extent that, by the time the complete cost of the line has been refunded, the farmer is using enough electricity to pay interest and depreciation on the investment and still leave a fair margin of profit.

No central station company need expect the farm business to pay from the very first, for the farmer must be educated to the many and varied uses of electric current before he really becomes a paying customer, and the only way in which he can be educated successfully is through actual experience.

The character of the farm load makes it desirable business from the central station standpoint, in that it is "off-peak." The lighting peak very rarely corresponds with those of the city customers and the power load comes on almost exclusively during the daylight hours, being heaviest during the summer months.

Very little can be expected from this type of business, unless an aggressive educational campaign is carried on. Progress will not be rapid until the pioneer central stations in this branch of the industry have given this new field a thorough test and proven conclusively that it can be made a financial success.

The writer's observation has been that those central stations who have had farmers on their lines for a considerable period are, as a rule, quite enthusiastic concerning the possibilities of this business. However, there is a great deal yet to be accomplished, and this can only be done by the active co-operation of both the manufacturer and the central station.

Heavy Machinery Used in Building Automobiles

THE tremendous demand for automobiles has compelled a revolution both in manufacturing processes and in machinery to render possible the great output of our larger factories; and on the other hand, these new methods have so reduced the cost of manufacture that it has been possible to also reduce the selling prices of cars of all descriptions, thus again stimulating the demand. Indeed, the history of automobile building, up to the present time, at least as far as relates to the better known makes, has been a regular repetition of this cycle of increased demand, reduced cost of production and lowering of price.

The changes in machinery have taken many directions, automatic operation has been greatly extended, existing machinery has been redesigned so that many pieces can be worked at one time, instead of a single piece, and a great variety of special machine tools have been invented for doing special classes of work particularly required in automobile building; but one of the most striking innovations that is seen in the larger works is the immense machines that have been introduced for working sheet metal.

Before the advent of the automobile the machinery for producing pressed steel work was limited in capacity. The chassis of the early automobile was usually constructed of wood, generally reinforced by strips of steel plate; but while this method answered well for a light car, something better was required when sizes began to increase. Then followed the chassis built up of steel angle and channel bars, riveted together; but this again proved unsatisfactory, and to meet the necessities of the occasion immense presses were constructed that were capable of forming steel plate into the required shapes, and of sufficient size for the purpose, and to do this great capacity was necessary, both in size and power, and the construction of presses of this size was hailed as a notable advance in mechanical engineering.

The presses for chassis building were the result of an absolute necessity, but after a while it began to be realized that, although very expensive in first cost, big presses could be used to very decided advantage in the production of some of the smaller parts, not only in the way of economy, but in the improved appearance of the parts. This is especially apparent in the improved, shaped fenders that are so much more attractive to the eye, and also so much stiffer and more durable than the old style that were formed from flat strips of metal. The cover illustration shows one of a number of large presses installed in one of the larger and more progressive American automobile factories for turning out fenders; and although not as large a machine as is required for chassis work, it illustrates the tendencies of the times, and the thoroughness that is characteristic of such establishments.

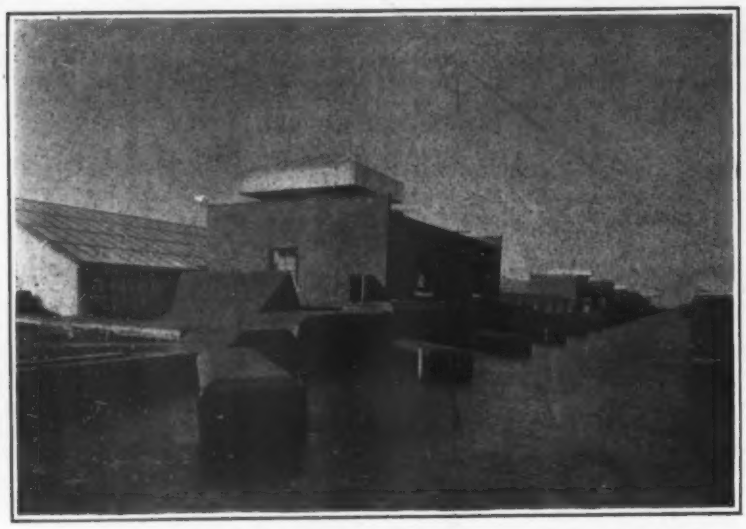
This monster press weighs 200 tons, and is capable of exerting a pressure of 400 tons, and was built at a cost of $15,000. It has two separate dies, each of which is operated by its own electric motor. The first die cuts the fender to the proper shape from a large sheet of steel, and then the second, or forming die, descends within the first die, and forms the crown of the fender, the entire operation occupying but a trifle over 60 seconds. It will be seen that this machine actually performs two operations with but one handling of the material, which is in line with present tendencies in all machine designing.

A Non-Corrosive Alloy

A METAL that will not corrode on exposure to moisture is very desirable for many purposes, such as for making faucets and other water fixtures, and fittings for yachts, and many alloys have been devised for the purpose, as no simple metal appears to meet the requirements satisfactorily. A new alloy that is claimed to be entirely non-corrosive has been recently patented by an American inventor, consisting of 82 parts of aluminium, by weight, 12 parts copper, 5 parts cadmium and one part silver mixed in a special manner. This alloy is said to be much lighter than copper or bronze, of good strength and to run well in casting.

Making Rain by Electricity

A NEW scheme for artificially producing rain is to be tried out in Australia, where there are large sections of land that would be valuable for agricultural purposes if sufficient moisture could be insured. A captive balloon at a height of 6,000 to 7,000 feet and anchored in the path of prevailing winds will be used to discharge electricity into the atmosphere; and it is hoped thus to cause sufficient ionization to provide nuclei upon which the moisture of the clouds will condense.



Pent houses on roof containing heat and ventilating apparatus, and ducts for distributing the air.

Erecting the heating apparatus in one of the pent houses, giving great heating surface.

A Remarkable Heating and Ventilating System That Conserves the Comfort of 15,000 Workers

The accompanying illustration shows a remarkable electric driven, air pumping, heating and ventilating system at the Ford plant in Detroit, Mich., and the unique method of utilizing the hollow concrete columns as air ducts, thus economizing floor space. The equipment to purify and "healthify" the air in the new six-story addition to the Ford American plant means to cool or warm as the case may be, and is of special interest. It was designed to give 15,000 employees comfortable and absolutely healthy working conditions—of getting 100 per cent human efficiency, 100 per cent of the time—of making an enormous factory habitable twenty-four hours of every day.

It is maintained that in the hottest weather, it is on an average, about 20 degrees cooler in this air-cooled plant than it is outside. In the hottest of weather the air leaves the ventilating apparatus at 78 degrees cool. And there is very little change from the time it leaves the apparatus until it arrives on the ground of action.

This building is six stories high—contains 11,200,000 cubic feet of space and 939,000 square feet of floor area. The construction is of steel and concrete with steel window sash. The roof is constructed of concrete, covered with cinders and tar with gravel on top of this, and the vast area of sky-lights are constructed in the same manner as the side windows of the building.

The heating and air conditioning apparatus consists of eight separate units, operated by electric fans, with 56,000 cubic feet (per minute) purifiers and huge heaters, nine sections deep of 72-inch Vento, two stacks high. Each unit of apparatus is placed in its separate pent house on the roof of the building, so that the sources of the air conditioning systems are distributed most advantageously. The healthified air from the fan discharges through a large duct which leads onto the roof, and here it divides into two smaller ducts going in opposite directions. From these ducts it is forced into branches which connect with each series of the columns supporting the different floors.

One of the unique, yet important, features of this plan is that the heating, cooling and ventilating system takes up practically no floor space, nor does it interfere with the light or the power transmission equipment. Every bit of space is available for manufacturing or storage purposes. The columns, which house or conceal the flues or ducts for getting the air where it is actually needed, are hollow. They were formed by placing a permanent light gage sheet-steel duct properly centered and braced with wood forms fitted around the outside. This duct was filled with fine, dry sand to prevent its collapse, due to the pressure of the liquid concrete mixture on the outside. The air outlets on each floor were provided for in the making up of the wood forms for the columns. When the concrete columns were poured, openings were left at the ground floor line. When the concrete had hardened, the sand was removed through these openings, thus leaving a smooth air duct of the proper size within the columns. The air is thus distributed through the supply ducts and columns to the various floors. Each outlet in the column is provided with a diffuser and damper to give good distribution, and to allow for adjustment of the volume of air on each floor.

The heat is obtained from hot water pumped from the power house and circulated through the heating coils in the pent houses. Thus, when the pipes are cold the many blade fans cool the employees, and when the pipes are hot the fans warm the employees. When the weather is cold, fresh air comes into the pent houses through stacks, with openings under hood-shaped coverings. Adjustable dampers regulate the supply, which can be cut off entirely and the air within the building recirculated after being again washed and warmed or cooled.

It is of interest to note that the power for all machines in the plant is entirely developed by large gas engines, and the cooling water used in the jackets around the cylinders of these engines, as well as the air compressor jacket water, is utilized for heating purposes. It enters the coils at a temperature of about 150 degrees, and circulating through them, raises the temperature of the air forced in contact with them to about 120 degrees. When necessary, it is possible to circulate this water at a higher or lower temperature. This means a corresponding higher or lower temperature of air distributed through the building.

The abundant supply of fresh air afforded by this system sustains the energy of the workmen.

Handicapping an Army by Poor Sights

Writing on the subject of "Infantry Technic" in the Journal of the Military Service Institute Capt. J. H. Parker has some decidedly pertinent comments to make on the sights that are now fitted to our military rifles. "I have never been able to understand," he says, "the pseudo logic which perfects an accurate instrument and then imposes conditions which prevent the user of that instrument from availing himself of its accuracy. That is the condition we have in using the 'battle sight.' The rifle is one of the most perfect instruments ever made. With a properly adjusted sight hitting is merely a question of holding. But with the battle sight holding must be off, instead of on, the target; the rifleman has no definite point of aim, but must estimate the number of inches he must hold off the point to be hit as well as estimate the range. Such estimates introduce an element of inaccuracy which cannot be neutralized by any amount of skill."

The theoretical reason for applying such crude, elementary devices appears to be that the careless or stupid man will be thereby prevented from overshooting; but there does not seem to be any evidence that it will either prevent overshooting or undershooting, the rational result seemingly to be that the rational majority are to be handicapped, and their efficiency sacrificed on the more than doubtful possibility of getting mediocre results from an incompetent minority.

Following the same line of reasoning theories of "cones of fire," "beaten zones" and "collective effort" prevail, as well as superiority of fire through rapid delivery in which a speed of eight to fifteen shots a minute are fired indiscriminately. To all of these theories the writer takes decided exception, and maintains that the true problem of fire, considering modern conditions, is to make the greatest number of hits in the shortest possible time with a given amount of ammunition, rather than to attempt to frighten the enemy by a great noise.

Another point of current practice in this country which Capt. Parker criticises is the inadequate instruction in rifle practice now given in our army, only four or five days being devoted to this by each company; but this superficial training appears to be but a natural corralary to the use of inadequate sights and aimless system of firing.

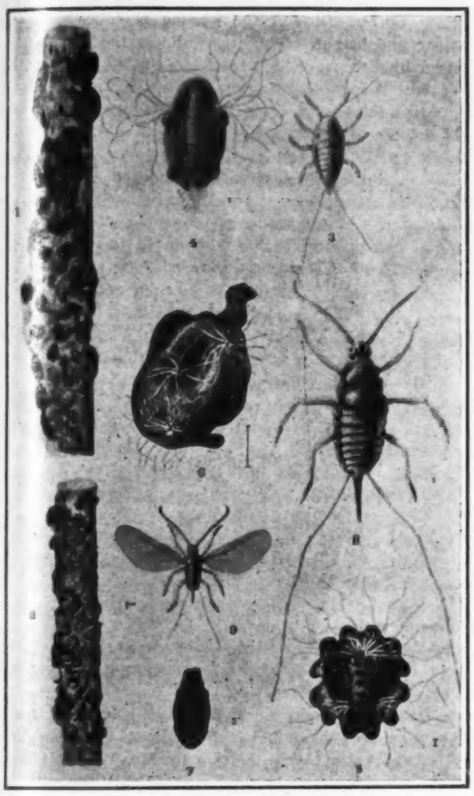
Electrically operated device that washes all dust from the air.

An aisle in the building. The columns form air ducts.

The Lac Insect

The Curious Insect That is the Source of Lac Varnishes

Lac is a resinous incrustation excreted by a scale insect known as *Tachardia lacca*. The mouth parts of this insect consist of a "beak" or sucking apparatus combined with a pointed lancet. With this latter the scale pierces the bark of the twig of the tree, and then inserts the sucking tube and draws up the sap. The insect may be likened to an animated siphon, since the sap continually sucked up through the beak is, after modification and absorption of some of its products, given out as an excretion at the anal end of the body. This excretion solidifies on contact with the air, and thus there is gradually formed round the body a "scale" or "cell." This scale or cell is popularly known as lac. Were only a single insect present on a branch the scale would appear as a circular dome-shaped reddish excrescence on the surface of the bark. Owing, however, to the production by the female of a very large number of eggs (as many as 1,000) and the habit of the insects, which indeed is common to many of the family, of living and feeding gregariously, closely packed on one twig, the scales or cells coalesce during their formation and result in the production of a continuous incrustation on the twigs which, on collection, forms the article of commerce known as stick-lac. From this stick-lac the product known as shellac is manufactured. There is a second substance obtainable from the scales known as lac-dye, for which formerly there was a considerable demand, which, owing to the introduction of synthetic dyes, has practically disappeared.



1. Healthy insects on twig. 2. Unhealthy insects on stick. 3. First instar, active age. 4. Female, 4 weeks after inocculation. 5. Female, 13 weeks after innoculation. 6. Dead female cell, with young emerging. 7. Male cell, 13 weeks after innoculation. 8. Wingless male. 9. Winged male. Reproduced from the Agricultural Journal of India.

The trees upon which the insects particularly thrive are the *Kusum* (Schleichera trijuga) and the *Palas* tree (Butea frondosa), the latter of which is known in Sanskrit literature by the name of Lakhsataru or lac-tree. The aboriginal tribes throughout India recognize the *Palas* tree as *the* lac-tree, and the industry would seem to have an antiquity of several thousand years in the country.

The cultivation and collection of lac was, and practically still is, chiefly in the hands of the aboriginal races of the poorer parts of the country, and the methods of propagation and collection still in force are those which were in existence centuries ago.

The Lac Insect.

The lac insect belongs to the great order of insects known as *Rhynchota* (*Hemiptera*) or bugs, plant lice and scale insects. The lac insect belongs to the family of *Coccidae* or scale insects, as they are commonly known. The plant feeding form of the *Coccidae* may be roughly divided according to the mode of life of the species into two great groups. (a) Those insects which move about during the whole of their life, and do not form scales; (b) those insects which, although active during a portion of the young or larval stage of their existence, sooner or later come to rest on the food plant, bury their proboscis in the succulent inner bark of the twigs of the plant and gradually build up by excretions a covering of scale round themselves, which may eventually completely enclose the insect. It is with the second of these two divisions that we are concerned here.

The reason for the production of the scales is probably primarily protective. As long as the insect keeps moving about it is not so completely at the mercy of predaceous foes, such as birds and insects, as is the case the moment it comes to rest and buries its proboscis in the layers of the twig. The production of a scale or covering which gradually incloses the insect removes to some extent this danger. But in spite of this covering the lac insect has still a number of insect enemies which prey upon and destroy it.

The newly hatched insect, or larva, is a minute red or orange colored insect, elliptical in shape, rather obtuse in front and more restricted towards the lower extremity. There is no obvious constriction between the head and body in front. The head has two small marginal eyes and two short antennae or feelers. There are six short legs on the body, which consists of nine segments; on the penultimate segment there are two very long hairs. There are two tufts of white, powdery, hairlike filiments growing from the sides of the thorax (the segments following the head) respectively, in place of wings, and a tuft of the same kind, bifurcating and curling outwards on each side, projecting from the anal orifice posteriorly. The length is 1/40 of an inch, and it is impossible to distinguish sex at this stage of life.

The Female Insect.

By the end of a month the female insect has become considerably swollen and enlarged, having excreted a certain amount of a resinous scale substance (lac) around herself. She is then 1/13 of an inch in length. By now it will be seen that the antannae, legs and head (chitinous) outer portions of the body have disappeared, having become incorporated with the resinous secretion. The eyes have disappeared and if the resin is dissolved away the insect will be seen to have become a dark red, elliptical, smooth shining sac (Fig 4 in Plate 1), the only appendages visible being the three white tufts or hair-like filaments at its obtuser end, and the beak or proboscis at the elongated end, which is now fully developed. The proboscis consists of a fleshy projection situated beneath the insect at a short distance from the head. This structure consists of several hairs and spines, which together form the penetrating organ by which the bark is pierced and the tube through which the sap is sucked into the body. The three apertures from which the white tufts proceed, and which now can be seen to open through the resinous incrustation, are situated at the thoracic and posterior ends of the insect. The two former appear to replace the wings, whilst the latter proceeds from the anal aperture. The white tufts projecting from these consist of the extremities of the trachea (the air tubes which ramify through the body of an insect and form the air breathing apparatus are termed trachea) and are covered with a white powder.

The female after impregnation by the male, when she is about two and a half months old, continues to grow in size and exude lac incrustation for another two and a half months. Further changes gradually takes place in the body during this period, the ovary becomes greatly enlarged, occupies the greater part of the body, and is filled with a bright red fluid. During the last month of life the eggs are gradually formed within the ovary from this fluid.

The chief points of interest therefore in the interior of the body of the fully grown female are the irregularly massed bundles, without any apparent order, of the white trachea, many of whose extremities protrude through the three apertures (two small thoracic and one large anal) on the surface, as described above, and the ovary. This ovary is of immense size, almost filling the body, and contains the red coloring matter known as the lac-dye of commerce.

The scale which covers the female insect when isolated from the rest is seen to be circular, with twelve notches around the base, six on each side. The outer surface is covered with a kind of white powder which is concentrated here and there in little spots, being chiefly confined to the three white tufts that radiate from three small holes situated in the incrusted scale. These holes are placed irregularly, two being closer together than the third, which is the anal and largest one, the others being spiracular oraficees (breathing openings). These three openings are continuous with the three corresponding apertures before described, as situated in the insect, and from which the three white tufts protrude.

The Male Insect.

About two months and a half after the small red larvae first issue small red insects are to be found actively crawling over the newly formed incrustations of the females. These are the male insects.

1. Branch of Butea frondosa (dhak) well covered with a fully developed lac. 2. Branch showing lac incrustations with newly hatched grubs swarming out of it. 3. The same enlarged. 4. Transverse section of female lac cells exhibiting their structure. 5. Longitudinal section of the same.

The male is a little larger than the larvae when it first issues. It has larger antennae, which are hairy-plumose and consist of seven joints excluding the two basal ones; there are four eyes, two lateral and two placed underneath the head; two long, hair-like appendages project from the upper side of the penultimate segment of the body; on the last segment there is a beak-like horny process that is curved downwards and is connected with the generative organs. The changes undergone by the male larvae in its development consists therefore of a slightly increased size, in a marked development of the antennae, in a differentiation of the head and the addition of two large eyes beneath, whose function appears to be to enable the male to see the openings on the lac connecting with the female generative organs.

The male larvae, as in the case of the female, after a brief period of activity after first hatching, come to rest on the twig and bury their proboscis in it. A scale is formed, but this differs from that of the female in being slightly smaller, narrower and elliptical in shape and in having no serrated base or holes or white hair-like appendages. This scale is open at its posterior or unfixed end, and the male on maturing leaves it at this end by elevating it and crawling out backwards.

Life History.

The insect usually passes through two generations in a year, although there may, in some parts of the country, be a third. The periods when the young larvae are seen to swarm upon the trees are about the first week in July and again in the first week in December.

The larvae on leaving the incrustation crawls to a neighboring twig and searches for a suitable soft, sappy part, and then, piercing through the cortex, buries its proboscis in the tissues and comes to rest in this position. During the search for favorable situations large numbers of the young grubs die either through being unable to travel the necessary distance to find a suitable twig to feed upon, or owing to their inability to pierce the cortex and obtain nourishment. Unless the young larvae can find a suitable spot within a few hours it dies.

As soon as the larvae come to rest they begin to suck up sap, and to exude the substance forming the scale, and owing to their habit of swarming together in large numbers, and fixing themselves upon the twigs closely together, the cells, as they enlarge, gradually coalesce and thus produce the thick incrustation commonly known as lac.

Some two and a half months after the period of swarming the male insects mature and leave their cells, and crawling over the lac incrustations impregnate the females through the anal opening above described. After pairing the male dies. Further changes take place in the female after impregnation, the ovary becoming greatly enlarged and filling the greater part of the body, and it becomes filled with a bright red fluid in which the eggs are formed. The female continues to suck in the sap of the twig and to exude the lac incrustation for about two and a half months, when she ceases feeding, and during the last, or sixth month of her cycle of life, the eggs are gradually formed. It has been estimated that each female produces as many as a thousand eggs, of which 5 per cent are males, and as these become mature the mother dies, being composed at this time of little more than skin. On hatching out the larvae issue either through the anal orafice, or through ruptures in the skin. Of the brood that swarms in December the males have wings, by means of which they are enabled to reach other trees where males are generally scarce, and thus the complete impregnation of the females is insured.

The Food Plants.

The trees which form the commonest hosts for the lac insect are the *Kusum* (Schleichera trijuga) and the common *Palas* or Dhak tree (*Butea frondosa*) of India.

Over eighty other trees upon which these insects feed are listed in the report, particular species being valued for propagating the insects in different areas of production.

Like all scale insects the lac insect must be looked upon as an injurious pest to the trees upon which they feed, since the drain of sap from the small twigs by what may be termed these animated siphons results in the twigs eventually drying up and dying. It is probable but rarely, however, and that only in the case of certain species of tree, that the latter are ever killed by the insect.

Enemies of Lac.

The lac insect has to contend against enemies of various kinds, including animals, birds, insects, fungi, natural influences, forest fires and man. Birds and squirrels prey upon the larvae, while monkeys and ants feed upon the sweet incrustation. The monkeys also do considerable damage from mischief, and the ants destroy many insects by nipping off the white filaments, which are connected with the respiratory apparatus of the lac insect. There are a number of different kinds of ants that injure the lac industry, and besides there are many other injurious insects and parasites of various kinds. There are also several species of fungi that prey upon scale insects, but little is yet known about such infestations of the lac insect. Unseasonable heavy rain at time of swarming of the young larvae often causes great damage; while hail and frost also cause injury. The primitive methods of collecting the lac, in which no attention is paid to the future welfare of the tree, has a prejudicial result on the industry.

Distribution and Cultivation.

The lac insect is widely distributed in India, and a peculiarity is that whereas it flourishes best on one or more particular trees in one locality, in a different part of the continent it will be found to thrive on other species, even though the trees upon which it does best in the former area may be present in the later. The explanation may be either that the host tree may vary with the amount of moisture in the atmosphere and conditions of temperature; and there may be more than one species or race of lac insects.

For many years the lac industry in India was wholly in private hands, but for some time the government has been exploiting its forests; and all interests are giving more attention to methods of cultivation and propagation, and to the improvement of the product.

The best lac is obtained from the *Schleichera trijuga* and is the light golden resin known in the trade as *Nagali*. From this the most valuable orange shellac is made. The next best comes from the *Butea frondosa* and is known as *bahisakhi* or *katki*, acording to the month in which it is gathered. It is darker in color than the *nagali* and the shellac is consequently less clear and bright. These are almost the only varieties used by European firms, but the native factories, most of which turn out a very inferior article, utilize the produce of almost every tree on which the lac insect is found.

In India lac enters very largely into the agricultural, commercial, artistic, manufacturing and domestic operations of the people. Large numbers of people are employed in the industry. In the village it is used either as a varnish or a color medium in the production of tables, bed posts, chairs, boxes, platters etc. The silver and coppersmiths employ it in their trades, as do the makers of shields and swords, which are varnished over with lac. The material is employed in the manufacture of pottery in many districts, and by jewelers and in the manufacture of bangles by the lower classes. On many kinds of toys lac is used for coloring; while a great variety of decorative articles are made entirely of lac.

The Trend of Electrical Development

A Discussion of the Limits of Efficiency

In an address delivered as president of the American Institute of Electrical Engineers, Mr. Paul M. Lincoln traced the progress of some of the developments and practices that have marked the paths which the electrical engineer has traversed in the past, with the object of obtaining some idea whither these paths may lead in the future; and he came to the conclusion that the rate of improvement must be slower than it has been in the past, and that if there are to be revolutionary improvements in the future they must come from a fundamental change in method rather than from the continued improvement of existing methods.

"He remarked that as regards efficiency electrical apparatus has always been recognized as being in a class by itself. Mechanical energy can be converted into electrical and *vice versa* at an efficiency ranging up to 97 per cent or even more in favorable cases; and he thought it a safe statement that the average efficiency of the conversion of mechanical energy into electrical by generators or electrical into mechanical by motors, including all sizes under actual operation, will reach 90 per cent. But because the size of the average electrical generator is much greater than that of the average motor, and because the generator can be operated at higher average loads than the motor, the average efficiency of converting mechanical into electrical energy is higher than that of the reverse process, and, therefore, while the average generator efficiency is well above 90 per cent, it is doubtful whether the average motor reaches so high a figure. The general conclusion must be that no development of a revolutionary character can be looked for in this respect; our ability to convert mechanical energy into electrical and *vice versa* has reached so high a value that even if we could obtain perfection itself we could add only a matter of 10 per cent to what has already been accomplished. Nor can anything revolutionary be expected in regard to the transformation of electrical energy from one form into another; the efficiency of some of our larger transformers, for instance, exceeds 99 per cent, and the rotary converter, for changing alternating into direct current, attains efficiencies approaching 98 per cent.

PRIME MOVERS.

"Of recent years there has been a marvelous improvement in prime movers. The early attempts to develop power at Niagara Falls constitute a significant commentary on the status of the water-wheel in the late 'sixties and early 'seventies of last century. At that time the building of the Schoellkopf Canal at Niagara made available a fall of about 215 feet on the American side, and of this head the least progressive of the earliest wheels utilized only 15 feet or 20 feet and the more progressive up to possibly 40 feet or 50 feet. Not only was it impossible at that time to obtain water-wheels that would work under more than these very limited heads, but the efficiencies of those that were used were far below those attainable to-day. Now water-wheels have no limit in head except such as is imposed by the strength of available materials, and efficiencies up to 90 per cent are expected as a matter of course. Perfection would thus add only 10 per cent to the best of modern practice and 20 to 25 per cent to the worst, and therefore no startling developments need be expected so long as the law of conversion of energy holds.

"In thermodynamic engines the use of the turbine permits efficiencies that were out of the question with the reciprocating engine of Watt. Some of the best modern turbines attain 75 per cent or possibly a little more, of the Rankine cycle efficiency, and in them perfection would add only 25 per cent. This statement, however, is true only of the best modern practice; only with prime movers of the largest size and most modern design and construction can so close an approach to the ideal be realized, and as capacity is reduced it becomes rapidly more and more difficult to attain the higher degrees of efficiency. This must always remain one of the potent factors in the economics of power supply, and is, and must be, one of the fundamental reasons why central station supply of electric service must prevail as against isolated plant supply. Central stations can use units which are larger and can be worked at higher average loads than the isolated plant.

IMPROVEMENT OF THERMODYNAMIC EFFICIENCY.

"One suggested means of improving the efficiency of the thermodynamic engine is by increasing the temperature range through which the working fluid is used. The only two ways of doing this when using steam are to increase the superheat or increase the pressure. Increasing the superheat over the best modern practice does not promise results commensurate with the expenditure of heat required to produce this superheat, since increase of the temperature at one end of the heat cycle simply involves a loss in the efficiency at the other end, and there is a fairly definite limit to the superheating of steam beyond which it is useless to go. Increase of pressure does promise results, and probably the tendencies of the future will be in this direction.

"Another promising method of increasing temperature range is that to which attention has been directed during the last year or two by Mr. W. L. R. Emmet, of Schenectady, who has pointed out the advantages of using mercury as the working fluid in a steam engine for temperature ranges above those available with steam. After working the mercury through a given temperature range, the heat remaining in the mercury is transferred to water and the steam thus made available is again worked through a lower temperature range. The advantages of this are that the steam is in practically all respects the same as in standard steam turbine practice and the mercury cycle is closely similar to the steam. Additional energy is made available from the same amount of initial heat due to the greater temperature range obtainable by the use of the mercury. The main disadvantage is the poisonous nature of mercury vapor and the difficulty of absolutely preventing its leakage at the high pressures and temperatures of the mercury boiler. These practical difficulties make it too early to predict whether or not this method will work out as a feasible solution of the thermodynamic engine problem. However, it can be said that, without some such method or device, the future is not likely to bring any revolutionary improvements in thermodynamic engines over the best of modern practice.

SIZE AND PRICE.

"The size and capacity of generating units will hereafter be fixed by the conditions to be met, and not by inherent limitations in the engineer's ability to produce units of any desired outputs. Units of 30,000 kilowatts capacity are in service, and still larger ones are projected. The presidential address of Mr. A. E. Kennelly, delivered in 1898, constitutes a convenient milestone by which to judge progress. He stated that in 1884 a 50 kilowatt generator was considered a large machine, and a 100 kilowatt Edison steam dynamo was justly called a 'jumbo,' whereas in 1898 the largest generator built or building was of 4,600 kilowatt capacity. Thus in the fourteen years from 1884 to 1898 the maximum size of generators increased 46-fold, while in the seventeen years since that time the increase has been only about seven fold.

"Mr. Kennelly stated that the price of dynamos in

1882 was about 20 cents per watt of output, whereas in 1898 dynamos of similar running speed for comparatively small sizes without switchboards cost about 2 cents per watt. The speed and sizes of these units were not mentioned, but in comparison it may be stated that prices are now frequently quoted below ½ cent per watt. Again, the improvement in the last seventeen years has not been so marked as in the previous fourteen years, and in the next succeeding period it is probable that a still smaller degree of improvement will occur."

UTILIZATION OF POWER.

In the latter part of his address Mr. Lincoln gave a few comparisons with the past in regard to the utilization of power, and expressed the conviction that the progress of the future will come from improvements in methods of application—a field that is inexhaustible.

"He pointed out that most of the modern development of electrical engineering has taken its initiative from the supply of electric light, the first practical application, in point of time, after the telegraph. In 1898 Mr. Kennelly remarked that the price of a 16 candle-power incandescent lamp, which 16 years before was about $1, was about 18 cents. The best lamps in 1882 gave about 0.28 mean horizontal British candle-power per watt under laboratory conditions, and about 0.20 under commercial conditions, and the highest pressure for which they could be obtained was about 110 volts. In 1898 lamps were obtainable giving normally 0.4 mean horizontal British candle per watt, while under commercial conditions the average lamp developed about 0.25 candle per watt. They could be obtained for pressures up to 240 volts, and were frequently installed on 220-volt mains.

"Mr. Kennelly thus recorded an improvement in 16 years of about 50 per cent in the cost of the lamps to the consumer and of about 50 per cent in efficiency. But thanks to the introduction of the metal filament lamp we have in the seventeen years since he wrote improved our maximum efficiency about 1,000 per cent —a truly marvelous advance. Yet in this field we have a long way to go without reaching a possible limit. It is true that the melting point of the now available materials seems to place the limit of efficiency at a point not much higher than that reached at present, but when the efficiency of the best lamps is compared with that of the fire-fly, evidently we have a long way to go before we reach perfection.

POWER TRANSMISSION.

"In the matter of power transmission, progress during the past few years has been remarkable. In 1898 Mr. Kennelly stated that the electric transmission of the power of falling water was a branch of engineering that had come into service since 1884, and was making rapid strides, owing to the recent successful employment of high voltages and multi-phase alternating currents. It was estimated that about 150,000 kilowatts of this class of machinery was then installed in the North American continent, commercially transmitting power to various distances up to 85 miles, at various pressures up to 40,000 volts. Since he wrote the maximum transmission voltages have gone up about 3¾ times; the maximum then was 40,000 and now is 150,000 volts. The maximum distance of transmission has gone up about 3½ times, 245 miles as against 85, and the installed capacity of water power plants on the North American continent about nine times, 1,350,000 instead of 150,000 kilowatts. He also mentioned that insulation testing sets had been made for producing alternating pressures up to 160,000 volts effective. In this respect we can go at least 10 times better than he reported, 1,000,000 volts from transformers having been made available on more than one occasion while in some cases the voltage available from transformers has been pushed even higher. Power transmission since Kennelly made his record has advanced with probably greater rapidity than any other branch, but the president of our Institute 17 years hence will not be able to claim any such advance as we may now claim over 1898.

"Another limit that we are approaching in the matter of power transmission is the economic one. Transmitted power costs more than that generated at the points of delivery on account of the cost of and the losses in the transmission line. There obviously is a limit to the investment that can be made in transmission lines while still permitting a supply of power with the same economy as it can be generated upon the ground. This consideration, coupled with the rapid advance in methods of generating power from steam, has placed an economic limit to the transmission of water power, so that we cannot expect any such advances in the future as the past ten or fifteen years have given. That there will continue to be improvement and advance no one can doubt, but the rate certainly will be diminished."—*Engineering Supplement of the London Times.*

Some Features of Road Construction

Road Surfacing and Corrugation

The meetings and congresses on road construction and maintenance which have been so numerous during the past few years have gradually changed in the character of their proceedings from talking at large on generalities to the discussion of the details upon which the success of good construction and maintenance depends. The necessity for really strong, well-made foundations has silenced the supporters of half measures, and discussions are now devoted to the selection, and most useful methods of employment, of the best surfacing materials. It will probably be a long time before the proper quantity and quality of the labor employed will receive the attention they need from road authorities for constant and competent repairs, but meantime data are being collected by road engineers with respect to the materials, the best methods of construction and their behavior in practice under all sorts of vehicular traffic. The search for the cause of the failure of some kinds of surfacing has turned attention not only to experimental trials of various materials and of tar and bituminous mixtures and aggregates, but also to traffic statistics. Laboratory experiments have helped a little, but it is trial on the large scale in roads and streets that has given the only practical definite information which the road engineer of some power of original thought can proceed to use with some feeling of certainty of success. Study of statistics of density of traffic has helped some, but has equally misled others. Some have been misled so far as to conclude that their only hope of success is to have nearly all the heavy modern traffic declared to be "extraordinary traffic," a conclusion which leads to the contradiction that a majority is necessarily in the wrong. Others have been led to an equally erroneous interpretation of statistical evidence relating to the relative detrimental effect of various kinds of vehicles and vehicle construction. The reasoning of both classes leads to the conclusion that the vehicles of the now great mechanically propelled traffic must be made to suit the average road of to-day rather than that the roads must be made to meet the requirements of the traffic. Those who would place most of the heavy traffic under the ban of "extraordinary traffic" would favor a vehicle tax which would in effect reintroduce a toll system which would be as bad in effect as was the system in vogue before the repeal of the Turnpike Acts, and would be a tax on traffic which would increase the cost to the consumer under the guise of saving his pocket with respect to cost of road maintenance. The experience of those who have adopted the best practice is that the most costly methods of construction are also the most economical. There can now be no doubt that for all main road and heavy traffic roads not only must the foundation be the best that can now be made, but the methods of construction of the surface and the use of the materials proved best by extended practical experience must, with some modification of present practice in consolidation, cost least as being of the greater durability and costing least in maintenance. We need not here consider the selection of the different kinds of stone or rock materials available in different districts, but it may be urged that the methods of their employment and consolidation are to a great extent the cause of the unsatisfactory condition of the surface after comparatively short periods.

One of the questions discussed at some length during the discussion by the conference last June and July was the cause and effect of the corrugation or road waves. The explanations of this varied so much that if all were correct no corrugations could exist. According to some, it was due to the prevalence of large numbers of vehicles, all of the same or similar wheel base, wheel diameters and weight, but those who suggested this explanation also admitted that the tonnage of vehicles of other kinds in which every one of these particulars varied, was in some cases even greater than that of the vehicles of precisely similar patterns. Others instanced the motor omnibuses, especially in Greater London, being of similar pattern, were an effective cause, though they ran on rubber tires, while all the other traffic with wheels varying from 18 inches upward was of far greater tonnage. Others found that vibration, periods of springs, vibration of engine were an effective supplementary cause, although these vibration periods would neutralize each other, and engine vibration on the spring-carried frame could have no effect at any vehicle speed. Others, however, of greater experience and capacity for interpreting the evidence afforded by their own observations, were in agreement that this road corrugation or waviness was due more to defect in original construction and almost always follows the method of consolidation by rolling. Corrugation is so often assumed to be a new thing and having the modern motor vehicle as its cause, that it is well to remember that it is not only not a new thing, but has been the cause of much trouble to road engineers and surveyors for many years past; in fact, its cause with respect to macadam roads was pointed out in 1898 by the then president of the Society of Engineers, when not only was the waviness produced by the heavy roller in consolidating a new surface described, but the destructive effects on the materials down to a considerable depth caused by the rolling of wheeled vehicles was appealed to as an evidence of the rolling effect. Anyone who has watched the progress of a steam roller in rolling a new coating of macadam metal will have seen how the recurrent hard and soft places in the bed being rolled are produced, not only by the propelling rollers, but by the front roller which is not propelled. The material is pushed along until the crest of the wave in front of the roller can no longer be pushed forward. It is then mounted and the roller in its progress repeats this action. During the movement of the roller from crest to crest a sorting action takes place in the material and the smaller pieces tend to separate themselves from the larger pieces and reach the lower part of the coating. An apparently level and homogeneous surface is produced, but after the wide roller has done its work, the wheels of ordinary vehicles begin their work. Many of these have considerably greater load upon them per inch width of tire and have wheels of much smaller diameter than those of the roller. These soon begin to repeat with greater effect the kneading action of the steam roller, and they bring into relief the hidden waviness originated by it. The original waviness is greater with the large size of macadam often used even yet, and although covered with what should be a sufficient coating and carpet of finer materials, the original waviness is sooner or later made apparent. It has been found that cross rolling has a good effect in minimizing the original waviness, but cross rolling cannot be everywhere practised, although much may be done by departing wherever it may be possible from continuous parallel rolling. With some of the more recently constructed road surfaces made with smaller materials from the beginning and with a well-applied bituminous carpet, the corrugation is less rapidly produced, especially when a concrete foundation is used, and the surface finished with a hard bitumen carrying the greatest possible quantity of small grit aggregate. A spell of hot weather will, however, put even these surface into a condition in which they are more easily kneaded, and corrugation will then arise without any reference to the condition of the sub-surface. The sandy asphalts which may wear with evenness during the greater part of the year will become wavy for this reason during or following hot weather.

The causes of corrugation are thus in the original construction of the macadam type of road, coupled with the after-kneading by ordinary vehicles; and in bitumen-coated roads by kneading even when the bitumen carpet is directly on a strong concrete foundation. Roads such as those which used to be surfaced with materials not rolled, but only gradually consolidated by traffic, were less subject to waviness than the roads of to-day, partly no doubt owing in some cases to the smaller tonnage of traffic, but more to the fact that the stones gradually found their places among each other, and to the irregularity of the rolling by the wheels of common vehicles. It would seem that the only way to obtain a road surface which will not become wavy is to make it on a base in which no interstitial movement can be induced, such as concrete, and coat it with a carpet which is compounded with a grit aggregate bound by the smallest possible quantity of hard bitumen, so that the surface would be friable rather than capable of being kneaded by the wheels. It has been observed that quite a thin coating of purified tar on a concrete floor will stand very heavy wheel traffic, and it is possible that such a coating frequently renewed would meet a large part of the requirements of urban and suburban streets and many roads. When the macadam type of construction is used, the metal should be sorted into something like compactness and rammed into solidity rather than rolled. Machinery for this does not exist, but probably could be devised in practicable form.—*The Engineer.*

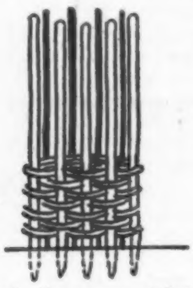
Ductile Tungsten

Tungsten has heretofore been known as a brittle gray metal entirely lacking in ductility, but recently a new form of the metal has been produced which is so ductile that it can be drawn into wire and used for lamp filaments. The more it is worked the stronger it gets. Specimens 2.8 millimeters diameter have shown a strength of 460,000 to 490,000 pounds per square inch, as compared with steel piano wire at 507,000 pounds.

Protecting the Frontier*

Some Methods of Constructing Trenches

THE total length of the frontier that Germany has to defend is some 600 miles or 1,068,000 yards. The general disposal of troops for defense, in all armies, is about one man per yard, an equal number for local reserves, and double the number for general reserves. At first sight, this would seem to require some 4,272,000 men for the defence of the German frontiers, a total it is utterly im-



A gabion in the course of being made.
Upright pickets are driven into the ground in a circle and brushwood interwoven.

possible for Germany to produce; but there are certain factors by which this number may be reduced to perhaps one fourth, but certainly not below it. First, in every modern battle front there are innumerable gaps, due mainly to the extensive command of modern artillery, and partly to the fact that the natural features of the ground offer no tactical advantage to either side.

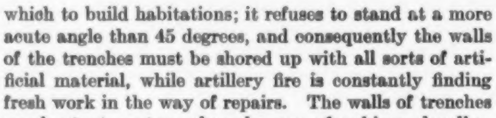
If one wishes to estimate conservatively, one can reckon an average of two miles undefended to every mile defended; this would mean a total of 1,424,000 men, but a still further deduction can be made from the portion of this force devoted to general reserves on account of the mobility the Germans enjoy. Instead of these reserves requiring to be half the total force, they might contrive with a quarter—that is to say, an amount equal to the firing line or the local reserves, and half the number of the two combined; they cannot, however, do with less.

This means, roughly, 356,000 men each to the firing line, the local reserves and the general reserves, or 1,056,000 men in all, and this is the minimum number which Germany requires to keep her eastern frontiers inviolate, and what is even more important she must, in dealing with an enemy of Russia's resources, maintain these forces at this strength over the whole period of the war, making good all wastage below this figure, for no corresponding wastage will affect the offensive powers of Russia and her reserves.

"Tommy's" versality threatens "Jack's" claim to the title of "handyman," for he is a carpenter, a miner, a basket-maker, a woodman, and also something of an engineer. The truth is that earth, while providing excellent shelter against bullets, is a plaguey material of

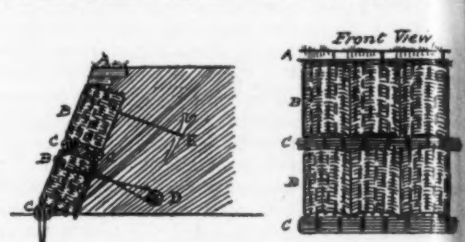
A finished gabion.
It measures about 2 feet 9 inches in length, and about 2 feet in diameter. Its weight is from 36 to 56 pounds, according to the size and dryness of the brushwood used in its manufacture. When filled with earth it is used to support and reinforce earth parapets.

which to build habitations; it refuses to stand at a more acute angle than 45 degrees, and consequently the walls of the trenches must be shored up with all sorts of artificial material, while artillery fire is constantly finding fresh work in the way of repairs. The walls of trenches are kept at a steep slope by use of gabions, hurdles, fascines, sandbags, or sods of turf, and the preparation of these devices involves a good deal of very irksome and unaccustomed labor which "Tommy" does manfully



The gabion in use.
A low parapet revetted with turf-sods and one row of gabions. A, turf-sods forming elbow rest. B, gabion. C, fascine pegged to the ground.

to an accompaniment of semi-humorous grumbles. The gabion is a cylindrical basket open at both ends and looking, at first sight, as if it could have no possible use in any capacity, but when stood on end and filled with earth its utility becomes apparent, for it makes a strong support to the earth parapets of a trench. Gabions may be made of almost any material which is capable of being



The gabion in use.
A high parapet revetted with two rows of gabions and fascines, showing method of anchoring the gabions. A, turf-sods. B, gabions. C, fascines. D, anchorage by means of wire and picket buried in parapet. E. Anchorage by means of fascine buried in parapet.

bent to a circular form, such as brushwood, canvas, sheet iron, wire netting, etc. To make a gabion of brushwood a circle of 10½ feet diameter is first traced on the ground and a number of pickets 3 feet 6 inches long driven at intervals into the ground at regular points round the circle. A number of small rods of brushwood are then woven in and out, the successive layers being continually pressed downward to make the webbing close. When the webbing is completed two larger rods are interwoven at both ends in order to strengthen the gabion, and the result is seen as in the diagram reproduced; the total task occupies three men about two hours, and since fourteen are required for every 100 superficial feet of trench it will be seen that it is no small task to provide even one line of trenches with this useful form of revetment.

There is a much quicker way of making gabions when the stores are available, for ready-made circular gabion bands of a substance technically known as "Willesden paper" are provided. One of these is laid on the ground and pickets are driven in alternately inside and outside the band, the remaining bands being then placed on the pickets. In ten minutes the gabion is complete. Gabions are also made of galvanized wire, but owing to their open mesh are of little use in light or sandy soil. Fascines are long bundles of brushwood about 18 feet long and 8 inches in diameter, and these are often employed in conjunction with gabions in the manner shown in the accompanying sketch.

* From *Navy and Army*.

A Bottle Filling Alarm

FILLING water bottles in a laboratory is generally rather of a nuisance, for it is certain that when a number are being filled some will be permitted to overflow. Writing in *Metallurgical and Chemical Engineering*, E. J. Hall, of the Columbia School of Mines, gives the following description of the device shown in the accompanying cuts, for giving warning when the bottle is full.

In Fig. 1 the center tube passing through cork reaches almost to bottom of water bottle. The angle tube is inlet and short vertical tube acts as a vent. As the bottle fills pressure is produced, causing mercury to rise till contact is made, closing circuit. The contacts by this method are very satisfactory, but the mercury is apt to spill and the volume of air in tube varies with the temperature, causing alarm to ring with water at different levels under varying conditions.

To obviate these difficulties devices illustrated by Figs. 2 and 3, which are self-explanatory, were tried the floats were made from ½ x 4 inches thin wall test tubes, weighted with mercury. In Fig. 2 the float is capped with a cartridge shell surfaced with silver foil. The wire contacts are of platinum soldered to copper leads with silver solder and fused into glass tube. The curved contact wire in Fig. 3 was rolled out thin to give it necessary flexibility.

These alarms have been in use for about three years, giving entire satisfaction.

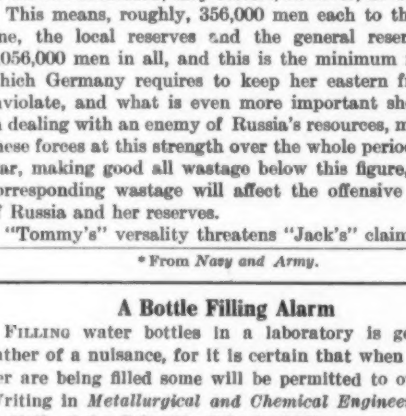


Fig. 1.

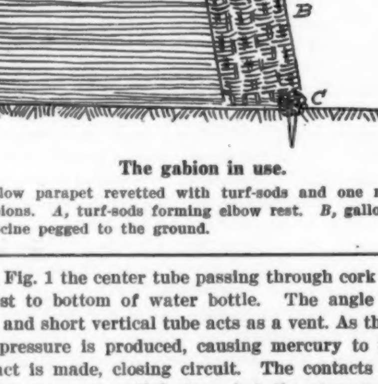


Fig. 2.

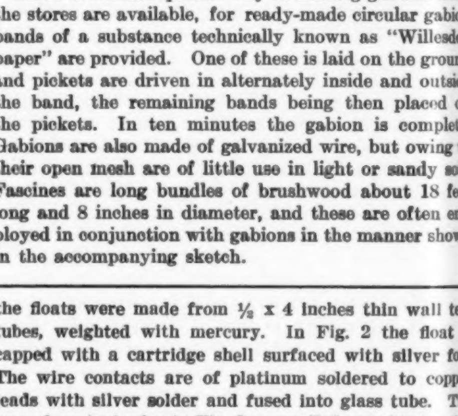


Fig. 3.

The original "grasshopper" and a modern Mallet locomotive.

The Atlantic has cylinders 10 by 20 inches, and uses steam at 5 pounds pressure. It weighs 6½ tons and can pull a load of 24 tons on a level road. The Mallett freight has cylinders 26 and 41 by 32 inches, it carries 210 pounds steam pressure, weighs 231 tons and can haul 1,500 tons.

Locomotives at the Smithsonian Institution

PROBABLY no museum collection in the world better illustrates the development of the steam engine, particularly the locomotive, than the exhibit of the U. S. National Museum at Washington, which includes two of the earliest original locomotives and numerous models and accessories.

As the result of a wager made by a resident of Merthyr-Ty'dvil, an important iron town of South Wales, that he could convey a load of iron nine miles by the power of steam alone, Richard Trevithick made the first engine to run on rails in 1803, and won the wager for his employer the next year. It has been claimed, however, that Trevithick copied the stationary engine built in 1800 by Oliver Evans, an American, who later attached wheels to a scow and propelled it by steam through the streets of Philadelphia in 1804. This curious creation, called the "Oruktor Amphilbolis," was the first motorcar to run on American soil.

A model of Trevithick's engine is to be seen in the National Museum, as is also the model of the engine employed by John Stevens in 1825, and his original tubular boiler. Other models illustrate nearly all the types which began to put in their appearance soon after 1828, when the "Stourbridge Lion" was built in England and shipped to America, where it was the first engine to run on full-sized rails. The museum possesses not only the model of this historic engine, but the original engine itself. The other original full-sized locomotive to be seen in the museum is the "John Bull," built by George Stephenson & Sons of England, and shipped to America for use in 1831 on the Camden & Amboy Railroad. It is interesting to recall that this old relic of early railroading in America made a round trip under its own steam in 1893 from New York to Chicago, where it was exhibited at the World's Columbian Exposition.

Among the models of early and historic locomotives are: George Stephenson's "Rocket," built in 1829; the B. & O. engine "Tom Thumb," built by Peter Cooper in 1829; the grasshopper type engine "Arabian," of 1831; the "Best Friend," used in 1830-1831; Baldwin's "Old Ironsides," constructed in 1832; the "Sandusky," built in 1837; and models of engines made by Asa Whitney in 1840 and G. A. Nicholls in 1848. Besides the two locomotives and the numerous engine models, there are in the exhibit, coach and car models, sections of rails, spikes, wheels, and models and parts of valves, pistons, and other early patented accessories pertaining to locomotives and railroads, all of which go far toward completing an absorbing chapter of graphic history in connection with this interesting and important commercial development.

The illustration shows in a striking manner the growth of the locomotive, but even here the full contrast is not shown, for a number of other Mallet engines have been built that exceed in size the one here shown.

Motor Cars for Railways*

RECENTLY a large party of engineers and others interested in motoring and railway work paid a visit to Birmingham to the Midland Carriage Company's works to inspect a 200 horse-power motor rail car built for the New Zealand Government Railway. During the past few years engineers have paid considerable attention to the application of the internal combustion engine to railway work, for, under certain conditions, the gasoline rail car has great advantages over steam and electric railway systems.

The New Zealand Government Railway are going to utilize the Thomas Transmission motor coach for suburban traffic, as steam is objectionable because of the noise, smoke, heat, and dirt. It is only in cases of continual and frequent service, and when there is a very large population to be carried on the line, that the large capital outlay of a purely electrical system, such as the London Underground, is a justifiable commercial proposition. Therefore, for suburban work alone the motor rail-coach is most suitable, and especially when coal or water is scarce.

In order to run larger and faster trains, railway engineers will have to look to the internal combustion locomotive, as up to the present, as exemplified by the aeroplane and road motor, the gasoline engine alone is developing greater and greater and higher and higher power for less weight per horse-power produced. Many motorists will remember the efforts of engineers to improve the transmission of the power of the motor to the driving wheels. To effect less loss of power many thousands of pounds sterling have been expended in experimental work. In 1911 the Thomas electro-mechanical variable speed gear was the outcome of work in this direction, and fitted to both pleasure and commercial motor vehicles it was highly tested by the technical department of the Royal Automobile Club, which awarded it the Dewar trophy as the best improvement in regard to motor vehicles for that year. Since then it has been further improved and developed on larger lines, so that it has been successfully applied to overcome the greater difficulties of railroad work when bigger loads have to be hauled, greater speed attained, higher power developed, and loss in transmission minimized.

The system has been fully described in the past, but it may be briefly stated that it comprises the use of two electrical machines, each about one third of the normal horse-power of the prime mover (the gasoline engine), and a planetary gearing that connects the electrical dynamos and motors with the engine and the load. This gives a mechanical top drive direct from the engine, while the flexibility of the electrical machine gives the intermediate gear ratios in place of the ordinary form of gear-box mechanism.

In the New Zealand Railway coach the Thomas transmission gear is used in conjunction with one eight-cylinder V-type 200 horse-power gasoline engine. Its seating capacity will be for fifty passengers, while it will haul two 25-ton trailers, each carrying about the same number, or 150 passengers in all. The conditions of its service are severe, as the coach is required to carry passengers and haul a 25-ton trailer up a grade of one in forty at fifteen miles an hour, the gross load being about sixty tons. Its maximum speed on the level is just over forty miles an hour, and it is estimated that the rail car will haul a gross load of eighty-five tons up the one in forty grade at about ten miles an hour. By itself the coach will take this incline at a speed of twenty-five miles per hour. One was struck, during a short run on this rail car, with the smoothness and ease of starting, silence in running, and simplicity of control. In fact, it was as easy to drive the rail car as any tramcar.

Motorists will be interested in the actual gasoline motor with its eight cylinders, set V-wise, of a bore of 7-inch and a stroke of 8-inch, opposite cylinders acting on the same crank. The main induction pipe has a Claudel Hobson carbureter fitted at each end, while two separate magnetos are provided, one for each set of cylinders. All the valves are on the outside of the V, so that greater accessibility is given, while two silencers are provided, one for each row of cylinders. As the rail car has to run in either direction radiators are fitted at either end and the engine is reversible. This is effected by a camshaft arrangement which may appear complicated, but is very simple in its action. The engine can be stopped and restarted in the opposite direction in a few seconds. The camshafts are fitted with small flywheels to provide against back-lash. Two direct-driven centrifugal pumps supply the cooling water for the radiators at each end of the car, and ordinary gear pumps for the oil-cooling radiators, fitted for cooling the oil that lubricates the planetary gearing and engine, one radiator for each. These pumps are all driven by the engine. Owing to the special method of reversing the motor the only member that reverses its direction of rotation is the crank-shaft, thereby allowing the pumps with magnetos and camshafts to rotate always in the one direction.

Westinghouse brake equipment is provided, the air compressor being directly coupled to the crank-shaft of the engine. The weight of the complete chassis is about eighteen tons, of which the engine transmission and radiators weigh about seven tons, the two electrical machines of about 15 hundredweight each being included in the latter weight. As the electrical gears give 12 speeds, including the direct top drive, and the control devices are fitted at either end of the coach, the handling is quite simple, and for short shunting operations the power is transmitted purely electrically.

No doubt, in a few years, we shall see the gasoline motor invade our own railway systems just as electricity has ousted steam on certain lines. In any case the rail car with gasoline motor is an accomplished fact, and a commercial commodity.

* From the *London Daily Telegraph*.

The Chemical Industries in the United States*

A Review of the Situation at the End of the Year 1915

By I. F. Stone

When your chairman asked me to address you on the status of the Chemical Industries in the United States at the end of 1915, I considered the subject with much trepidation, and felt that if I tried to speak on this subject I would be falling into a teeming caldron of trouble, as with conditions so abnormal as they are to-day, anyone trying to describe these conditions as they are, and as they may be for the next year or more, is very likely to prove a false prophet. But notwithstanding these conditions, I will do the best I can, and hope anything I may have to say will be of interest to you.

Right after the beginning of the war there was an immediate demand from all sides for products which had formerly been supplied from Europe, which were apt to be scarce as a result of the war, buyers attempting to secure as large supplies as possible in order to carry them through during this war, might it be long or short, and as a result the prices of European products immediately commenced to advance and finally reached the most fabulous figures. Those of us connected with the lines of business dealing in these products, then thought that no more abnormal and exciting condition could be possible. But strangely enough, now, a year after the war, conditions are more exciting than ever, in that most of the European products which were then procurable in some quantity have practically disappeared, while the demand for them still continues to a great extent, but is impossible to meet.

The products manufactured in America, not dependent entirely on Europe, did not follow immediately the advance of the European products, but gradually, as the manufacturers commenced to see how things were developing and what their cost of raw material would likely be in the near future, they advanced their prices until they are now many times the normal in a good many instances.

American manufacturers also began to consider the question of manufacturing larger quantities of what they were already making, and also taking up new products which formerly could only be obtained from Europe, and I am glad to say that a great deal of progress has been made along these lines. I can say definitely that the chemical industries in the United States at this time are developing rapidly, and are in a stronger and better condition at this time, the end of 1915, than ever in the past, and many of the products which are now being manufactured will, in my opinion, continue to be manufactured after normal conditions are again in vogue, and we need no longer be dependent on Europe for such products. I will be more specific as I go along, but simply wanted to mention the fact at this time that the condition and progress of the chemical industries had developed and are now in a stronger position than ever before.

At the time of the war, or just before the war, the two most important chemical products furnished by Europe to the United States, in this case by Germany, were potash and coal-tar products. We were entirely dependent on Germany for muriate and sulphate of potash which, as you know, are used very largely for fertilizers, and in a smaller way for the manufacture of potash products such as bichromate of potash, yellow prussiate of potash, caustic potash, and so on, the manufacturers of which were dependent on Germany for their supply of raw material. Unfortunately, since the war and the embargo on the shipment of potash to the United States, none is now being received; no substitute has been found, and in spite of the reports from the Department of Commerce that large quantities could be secured from a seaweed called kelp, which grows in beds or meadows along the Pacific Coast, belonging to this Government, nothing so far has been practically done to recover it. There are reputed deposits of potash in Utah and California, but again nothing practical has ever been done with them, so that at the present time consumers of potash or potash products are entirely dependent on what is left of the German shipments before and right after the war, and when these stocks are exhausted, no one appears to know what can be one.

On the other hand, coal-tar products; it was immediately discovered by investigation in this country, that we had large quantities available if they only could be recovered and developed. In other words, the production of benzol, which is the principal base for the manufacture of most coal-tar products and chemicals, could be immediately increased, and this was and is being done. Some of the large steel works, which formerly did not recover their benzol, are now producing it, and the production, which was about 3,000,000 gallons before the war, is now increased to about 15,000,000 gallons; and, while unfortunately, its demand for war purposes in the manufacture of explosives, etc., is so great that even the present supply is not sufficient, and prices are almost too high for manufacturers to use it for the manufacture of ordinary products not connected with war products, yet the fact remains that this product has increased in production over five times, and this production is here to stay, and at normal prices will be largely used for the manufacture of other products, which will develop with it. There is one use for benzol, for instance, which is practical and sure, and that is its use for propulsive purposes in automobiles in place of gasoline. It is being largely used in Europe for this purpose, and the only reason it has not been used here has been the limited production and the higher price, it normally being about double the cost of gasoline. With the present immense production, however, the cost has been reduced until now I believe that it can be manufactured and sold at a profit at the proportionate price of gasoline, and that this will be done as soon as the present war is over. When I say proportionate price, I mean that careful experiments for automobile purposes show that benzol has a propulsive power about 25 per cent better than gasoline, consequently would have 25 per cent advantage at the same price, so that even with benzol 25 per cent more in cost it would still be money value, but I also really believe that it could be actually produced now and sold at the same price as gasoline if it were necessary to do so. Therefore, the importance of this matter is obvious. Not only is the above true, but it is a fact that the use of gasoline for automobile purposes is so large that it is very difficult for the oil companies to produce enough to meet the demand, consequently the entrance of the new product for the same purpose will be very inportant, and a great relief.

Another large increase in production through the present conditions is the manufacture of aniline colors and other coal-tar products in this country, which will be much to the relief of consumers, who at the present time are unable to get anything like the supply of colors which they need in the conduct of their business. The five factories already established in this country before the war are all extending their production to their utmost capacity in keeping with safety for their investment, and I believe that in 1916 the production of aniline colors in this country will be at least three to four times the production before the war. This production could again be largely increased if the manufacturers were sure of some protection from the Government in the way of higher tariff, or Government manufacture of intermediate materials, which would enable them to get these intermediates at the same price as paid by European manufacturers; and then again, the putting into effect some anti-dumping clause which is now promised by the Government, to prevent the dumping into this country of colors at lower prices than they are sold for elsewhere, for the purpose of preventing their development and manufacture here. Whatever the Government may finally decide to do toward the protection of this industry, there remains the fact that a great impetus in the development is already under way, with the hope of Government protection, so that the Europeans will find them strongly entrenched in any event after the close of the war. I am speaking now of factories already in operation, but in addition to these there are many new factories projected, and some in operation. I have a list of 23 new factories, the last of them with a proposed capital of $15,000,000, and while a good many of these may not materialize, something will surely come of some of them. Up to now none have actually manufactured any aniline colors, but some are operating with a production of some intermediate products like aniline oil, beta naphthol, paranitraniline, etc. And, speaking of aniline oil, with the one factory established before the war and the increase in its works since the war, and the number of new factories making or about to make aniline oil, it looks as if the production of this product would be 8,000 to 10,000 tons as against the normal consumption of about 4,000 tons; in other words, the proposed manufacture seems larger than the consumption, but as the consumption is also increased, possibly the whole amount projected can be used. At any rate there will be enough manufactured in this country to take care of the whole consumption, so that Europe need not be depended upon.

Another article which has increased largely in production is carbolic acid, the consumption of which in the United States is about eight to ten million pounds yearly. It is true, however, that this has not been available for ordinary use, as most of the new factories have used their product for the manufacture of picric acid, which is sold for war purposes, with the exception perhaps of the works of Thomas A. Edison, who, in an interview said that his production was about 12,000 pounds daily which is used for his records. The point about this article is that practically none of it was manufactured here prior to the war, but it is now produced in large quantities, and after the demand for picric acid is over for war purposes, then the production can be used for other commercial purposes to the advantage of this country, and so relieve them of depending upon Europe for their supply.

Another article which has increased largely in production here is naphthalene, which is also a coal-tar product. Before the war the production in this country was about 2,500,000 pounds, while now it has increased to something like 7,000,000 pounds, perhaps more, the normal consumption being about 9,000,000 pounds, and the difference between what was produced in America and the total was obtained from England and Germany, which countries hereafter should be practically unable to ship over here, by reason of the new large production here.

This is about all I will say in connection with aniline or coal-tar products, but as it is obvious that there is a great development taking place in this industry, it is certainly a very satisfactory condition at this time. Now, to leave the aniline industry, and go to other products not connected with aniline, but the development of which has gone on very quickly since the war, I will refer first to barytes and barium products. Before the war there had been a yearly average importation to this country of crude barytes of about 40,000 tons, coming from Germany, practically all of which was used in the manufacture of lithophone, which was about the only product of barytes made largely in this country prior to the war. There are now six manufacturers who are turning out large quantities, and the business on this product will remain with the American factories. I wish to say, however, that since the beginning of the war no barytes has been coming in from Germany, but it has been supplied from mines and deposits in the States of Tennessee, Kentucky, Virginia, and Missouri, and possibly some others, and now the thing to do is to continue to use this American product and keep away from the European barytes. Formerly there was a duty of $1.50 per ton on foreign barytes, but this was reduced in the last tariff to 15 per cent, which was only about one-half. The German barytes was formerly delivered at a cost of about $5 per ton at such ports as Philadelphia and New York, the duty of 15 per cent per ton included, and the American barytes under normal conditions could not compete and can only sell now because no German goods can be secured. The German barytes tests higher in barium sulphate content, averaging about 96 per cent and almost free from objectionable impurities, and the consumer obtains a better yield at a lower cost than by the use of the available American barytes, which only analyzes from about 83 to 95 per cent barium sulphate, averaging, say, 92 per cent, and much of which is contaminated with iron. The point is then that a duty should be placed on foreign barytes high enough to offset the difference in quality and price and insure the continued use of American barytes by American manufacturers. In other words, the duty should be advanced, instead of standing at the present duty of 15 per cent per ton. In addition to using the American barytes for the manufacture of lithophone since the war, four or five responsible factories have started up to manufacture other barium products, such as chloride, carbonate, hydrate, nitrate, and binoxide of barium, which means an increased use of the crude barytes, giving still further production to American producers, possibly double the quantity formerly used, and it is important that American producers should continue to furnish the crude barytes to these factories in spite of the German competition, which is bound to come again after the war, and as far as I know an additional duty is the only way it can be done. With the manufacture in this country of the products just mentioned, most of which were never made in this country before successfully, we have a practically new industry created, which will make us independent of Europe in the future, some

*An address before the New York section of the American Chemical Society, October 8th, 1915.

f these factories being already in operation successfully, and the full production of all of them will undoubtedly be on the market before very long. This makes the barytes and barytes producers in this country practically a new industry and one which could be held in the future, and is of great importance.

Another product, the manufacture of which has increased largely in this country since the war, is carbon tetrachloride, which was formerly made exclusively in Germany, but later taken up by American manufacturers, who at the time the war began were probably producing half the consumption here. Since the war they have increased their plants very largely so that they are now supplying all of the American trade, and while still somewhat short of the requirements, new factories are being constructed, so that in the end the whole consumption of the country will be manufactured here. This article is perhaps not so well known, but is one of considerable importance, and the consumption is continually increasing in view of the many purposes for which it can be used.

I have given, up to now, the situation on such articles for which we formerly depended largely upon Europe, but the manufacture of which has increased largely in this country, which gives a distinct advantage and increase in our chemical industry. I will therefore now refer to a number of products which have always been produced largely in this country, and not so susceptible to European competition, simply to advise you of the condition of the manufacture of these articles and the present and future conditions regarding them.

First in importance, I presume, is the manufacture of such acids as sulphuric acid, nitric acid and muriatic acid, which are the basic materials for practically all of the great chemical industries of the country and on which there has never been any foreign competition, because largely of the heavy expense of transportation and the fact that American manufacturers were able to make such prices as to render the importation unprofitable. Up to within a few months ago they were able to supply the demand of the country as usual, but as the war ran on and the demand for ammunition and explosive purposes became larger and larger, the demand for acids increased to such an extent that at this time the manufacturers are unable to supply it, and as a consequence American consumers find themselves unable to get enough to conduct their business, or, when they do get enough for their present business, are unable to obtain any additional quantities for an increased business, so that the general situation on acids is very serious at this time. Many increases are planned and under construction, but it will be a number of months before they can be completed, and not much relief is looked for for some time to come.

Perhaps the next important manufactures in volume and value are caustic soda, soda ash and bleaching powder, all of which are now manufactured largely in this country, the quantity I am told being from 1,250,000 to 1,400,000 tons of the three products together. For a short time after the war, the manufacturers were able to continue their supply in their ordinary way, but the stopping of shipments from European countries to other countries by reason of the war, led to a demand for American manufacturers to supply this shortage, that is, countries that had formerly bought from England and Germany and which could not get any from Germany at all and not enough from England, turned to America for their supply, and this created a large export business, which brought the manufacturers to their full production and has kept them very busy up to this time. By reason of this unusual export demand and the consequent shortening of stock, the condition of these products means great prosperity to the American manufacturers.

Other products manufactured largely in this country are such products as the yellow prussiate of soda and potash, chlorates of soda and potash, bichromates of soda and potash, the manufacturers of which hold the whole American trade, as there are practically no importations from Europe. The manufacture of yellow prussiate of potash, however, is somewhat limited owing to the inability of manufacturers to get muriate of potash from Germany, so most of them are working almost exclusively on soda; and the paint manufacturers, who are large users, are now trying to make their Prussian blues from soda instead of from potash and, if successful, as some of them seem to be, the soda will probably be used exclusively for a long time to come, and there will be no need to depend on European sources for potash.

The manufacture of chlorate of soda and bichromate of soda continues without hindrance, and in increasing quantities, but chlorate of potash and bichromate of potash are apt to be somewhat limited owing again to their inability to get proper quantities of the muriate of potash, these manufactures depending, as far as I can find out, on muriate of potash which was brought in from Germany before or just after the war began, and while they are fortunate in having enough to go on with their manufacturing, it must be evident that sooner or later their potash products must stop and soda products will undoubtedly be substituted wherever possible.

The condition of another potash product is also interesting, speaking now of caustic potash, the manufacture of which was commenced in this country some years ago and up to the time of the war was constantly gaining in importance and production. Unfortunately, however, the manufacturers were dependent entirely on Germany for their muriate of potash, and when shipments of this were stopped the factory was compelled to slow up, and is now in a position where they can only make such a quantity of caustic potash for which they can secure the raw material. Should muriate of potash be found or produced in America, then this caustic potash could be made largely, but while depending on Germany muriate of potash must necessarily continue to be limited.

Another important article the manufacture of which has developed in this country is oxalic acid. The factory established some years ago, but up to the time of the war having trouble to compete with European product on account of the reduction of duty in the last tariff, was not able to develop the production as they wished; but since the war and the importation of foreign acid practically stopped, they have taken care of practically the whole American consumption, and will continue to do so to the limit of their ability. They are not yet able to produce the full quantity, so there is a considerable shortage in supplies, consequently the price is very high, but eventually there is no reason why this product should not be manufactured to the full extent of the American consumption and the business held here.

There are many other chemical products which are manufactured in this country, but not of enough importance to enumerate separately, so all I can say in finishing is that the status of the chemical industries in the United States at this time is very satisfactory, practically every manufacturer being engaged to the limit of his capacity, and from every indication this prosperity will continue for the following year, for the reason that most of them have made contracts covering their production for this period.

You will notice in speaking of these various products manufactured in America, I have made frequent reference to the tariff and the necessity of advancing the duty if articles manufactured are to be developed successfully; and while I have no intention of making this an address on the tariff at this time, it is so obvious that the tariff should be reformed upward to retain the present manufactures successfully, that I cannot help mentioning it.

Marine Semi-Diesel Engines

When the semi-Diesel engine, or hot bulb motor as it should more correctly be termed, first came to the fore in its application to marine propulsion, it was generally considered that, although it was simple, economical, and in many ways suitable for its work, yet it would have to be modified very considerably if it were to obtain wide employment. Yet now that the hot bulb motor has attained a really remarkable degree of success, it differs comparatively little in external appearance from the very earliest types of engine that were put into service. The hot bulb is still the same, and the lamps which are required for heating it up when starting and to which so much objection was originally taken, are not yet dispensed with, while the employment of the crank chamber as a scavenging pump is almost universal. There have, however, been many important changes in the internal design and construction, and how successful these have been is indicated by the fact that whereas only a few years ago an engine of this type of about 60 to 80 horse-power was considered of large size, numbers of motors of about 350 horse-power are now in operation, and machines up to 500 horse-power are in course of construction. This development in power is all the more interesting, as the design of the hot bulb engine from the theoretical aspect is exceedingly difficult, owing to the many uncertain factors that are introduced, so that all progress and all new designs are dependent upon the results and experiences which are gained in actual operation.

DEFECTS IN DESIGN.

Until a year or two ago the majority of hot bulb engines had what were, to the minds of most engineers, two distinct defects. In the first place it was necessary to employ water-drip in order to obtain the maximum power from the engines, and this injection of water into the working cylinder presented many undesirable features. Chief among these was that it necessitated carrying a large amount of water (almost equal to the quantity of fuel) on the vessel, and thus made very long ocean voyages in many cases impracticable. The second disadvantage was that with almost every type, although the blow lamps could be dispensed with when the motor was running under load, they had to be kept burning when it was running light and even sometimes when working at merely reduced power. As many of the boats for which hot bulb motors are peculiarly adapted are in service under conditions which necessitate the motor being kept running light for prolonged periods (such as in harbor work), this disadvantage was obviously a very real one and a source of much annoyance to those in charge of the engine.

Both of these defects are now overcome in the majority of the best engines of the hot bulb type. In some cases it has been accomplished by redesigning the hot bulb and cylinder head and adopting, as in the case of the Kromhout engine, a hot plate instead of a bulb with a water-cooled head. In the Bolinder motor a small vertical compressor driven directly off the crankshaft is fitted to aid in the compression of the air for scavenging purposes, though it does not entirely dispense with the crank-case compression that is common to all types of two-cycle hot-bulb engines. In the new Bolinder engine also a water-cooled head is used, and this is now common practice, although when the hot-bulb motor was originally introduced such an arrangement was not usual. With four-cycle engines, of course, no scavenging is required, but the number of such motors built is limited, and the type has by no means gained such general approval as the two-cycle motor. In most cases it is adopted where a high-speed engine is desirable, since the four-cycle machine usually runs at a much higher speed of revolution than the two-cycle hot-bulb set.

FIELDS OF APPLICATION.

So rapid has been the development of the hot-bulb engine that it now practically holds the field for all types of motor craft in which the engine installation is anywhere between about 100 and 600 horse-power. Below the former figure the kerosene motor is still very largely used, while above 600 horse-power the Diesel engine is better as a rule, since even this power necessitates a twin screw arrangement with a hot-bulb installation. There are, however, several motor vessels now in service in which hot-bulb engines totaling about 700 indicated horse-power on twin screws are fitted; in particular this arrangement has been adopted for the intermediate type of tank vessel used for coastal transport, especially in Chinese waters.

The employment of hot-bulb engines for barges and cargo-carrying coastal vessels has long been common, and during the past year it has gained considerable ground in its application to tugs, for which it is eminently adapted. Some such vessels are now to be seen on the Thames, and others have recently been ordered. In the opinion of those who have had most experience in both steam and motor tugs of this type it is probable that the steam-driven tug will in course of time give way entirely to that equipped with hot-bulb engines, since the economy to be effected by the employment of the cheap heavy oil suitable for hot-bulb motors will render the steam tug in comparison far too expensive to operate.

A particularly interesting recent development of the hot-bulb engine is its application to sailing vessels. In Norway and Sweden there are now in process of conversion at least fifty such ships of large size up to about 350 feet in length, and in Christiania a ship-owning company was formed at the beginning of the year specially to run at least a dozen large auxiliaries between Scandinavia and America. Several of the vessels are now in service, and the reports that have been received show that they are actually more economical to run than pure sailing vessels owing to the time they save on voyages.

The hot-bulb engine has not as yet by any means reached the limit of its development. There are obviously many ways in which it could still be improved, and were it possible to dispense with the use of lamps altogether the advantage would be very marked, while the abolition of crank-chamber compression would also be a desirable feature. Even in its present state, however, the motor can be considered a thoroughly successful machine, and the prospects of its further progress in the future are extremely bright. Up to the present its manufacture has not been carried out very largely in this country, but it is hoped that after the war a stimulus will be given to its construction in Great Britain on a larger scale.—*Engineering Supplement of the London Times.*

In a paper on the process of metal spraying, before the American Institute of Mechanical Engineers, the speaker pointed out that the process could not be used for coating materials that were afterward to be bent at a sharp angle, or used in a state of tension. It was also stated that the air pressure necessary for working the process had, by improvements in the apparatus, been reduced so considerably that satisfactory work can now be secured with but 18 pounds.

Purifying Drinking Water on the Field

A NEW process for rapidly sterilizing drinking water has been carefully tested recently in France with special reference to use in the field. The process, which was discovered by MM. Vincent and Gaillard, is based on the well-known antiseptic action of calcium hypochlorite, which has been made a subject of study by such authorities as Woronzoff, Winagradoff, and Kolesnikoff, Sternberg, etc., and particularly by Chamberland and Fernbach, for purposes of local disinfection.

The new method of utilizing this salt as a sterilizing agent for drinking water was presented by Prof. Laveran to the French Academy of Sciences on April 17th. He stated that Vincent had demonstrated the energetic action of calcium hypochlorite on pathogenic microbes, such as the bacillus of cholera, typhus, etc., while Traube and Schumburg have employed it for sterilizing water. The addition of alkaline hypochlorites to drinking water, as in "javellization" is very serviceable. However, the variations of composition with reference to the amount of active chlorine contained in javel water or its extract, do not permit them to be used without a previous analysis of each commercial sample, since the content of chlorine may vary in the ratio of one to ten or more.

Besides the active chlorine contained in javel water or Labarraque water is spontaneously transformed by degrees into inactive alkaline chloride. Hence it is necessary, even with the same javel water, if used at variable intervals, to make a chlorometric test. Hence, calcium hypochlorite offers definite practical advantages over the former, since it is not only richer in active chlorine but is more stable, and is more easily handled and used because it is a solid instead of a liquid.

After numerous attempts Vincent and Gaillard succeeded in preparing compressed tablets, each containing at the time of preparation about 3.5 milligrammes of active chlorine. This proportion decreases gradually to 3 milligrammes, but the latter amount is sufficient to purify a liter of water. These tablets consist of a mixture of 15 milligrammes of calcium hypochlorite and 8 centrigrammes of pure sodium chloride. After being kept for two months they were found to have lost only 0.0003 to 0.0004 gramme of their chlorine content.

The salt is a very important constituent because it facilitates diffusion and a very rapid dissolution of the active chlorine. Within ten minutes, though the tablet appears to be unmodified, three quarters of the available active chlorine has been dissolved. In the succeeding ten minutes almost the whole of the remaining active chlorine is liberated. Tablets of the calcium hypochlorite without salt added, on the contrary, do not give up the whole of their chlorine till the end of several hours though well stirred in the water. Hence, there is no need of crushing the former tablet. When simply placed in the water it remains for several hours in the form of a skeleton of calcium carbonate. This has the practical advantage of furnishing a visible proof that the sterilizing agent has been made use of. After the action is complete the mineral composition of the water is very slightly modified by the presence of a few centigrammes of salt and one centigramme of calcium carbonate. The alkalimetric and hydrotimetric degrees are not sensibly altered.

As to the chemical action on the organic matter in the water, the general result of over thirty analyses of natural waters, water in gutters, water polluted by fecal matter, water to which one centigramme per liter of peptone has been added and allowed to putrefy, etc., may be thus recorded: the content in ammoniacal nitrogen and in albuminoid nitrogen decreased in a ratio which varied from $\frac{1}{4}$ to more than $\frac{1}{2}$, or even $\frac{3}{4}$, according to the degree of pollution and the nature of the dirt.

The oxidizing action which begins to be shown at the expiration of ten minutes continues for many hours, ceasing in about 24 hours. It may proceed even as far as the transformation of the organic nitrogen into nitric nitrogen. A specimen of water which has undergone the beginning of putrid fermentation loses all odor after the action of one of the tablets.

The bactericidal effect is vigorously parallel to the amount of active chlorine dissolved. Cultures of typhic bacillus, of paratyphic bacillus *A* and *B*, dysentery bacillus, and cholera bacillus were diluted with a liter of sterilized water from the Seine or Vaune, in such a manner that the bacterial content was from 2,000 to 3,000 per cubic centimeter. The tablet of calcium hypochlorite was then placed in the water and vigorously stirred or shaken. Then every five minutes samples were taken out of 2 cubic centimeters of the water and planted in bouillon. The pathogenic microbes were always found dead at the end of ten or twelve minutes, sometimes even in five minutes. Bacillus *coli* was killed in the same length of time.

In water containing 1.3 milligrammes of organic nitrogen the destruction of the typhic bacillus and other pathogenic bacilli took ten to fifteen minutes. In water three times as rich in albuminoid nitrogen the addition of two tablets gave the same result. Non-pathogenic microbes (saprophytes) in drinking water are acted on very rapidly by calcium hypochlorite in direct ratio to the dissolution of active chlorine.

Water containing 3,040 bacteria per cubic centimeter contained only 180 at the end of ten minutes, and 60 at the end of an hour. In water containing 16,975 harmless (*banal*) bacteria per cubic centimeter the microbe content fell to 450 in ten minutes, and to 105 in an hour.

Drinking water to which the calcium hypochlorite tablets have been added can be drunk at the end of fifteen or twenty minutes. It has no appreciable taste. The method commends itself as simple, practical, absolutely innocuous, rapid and efficacious. Moreover, there is no elaborate technique requiring careful manipulation by experienced chemists.

It is to be hoped that similar tablets will be placed on the market in this country, since there are many situations in traveling, camping, etc., where they would be invaluable.

The Sudden Turning Grey of the Hair

THE sudden turning grey of the hair under the influence of great emotion is a phenomenon so remarkable that it has always aroused curiosity. The well-known historical instances, such as the case of Marie Antoinette, who is said to have become grey in the night before her execution, are open to some doubt, but several well-authenticated cases have been published by medical observers. At a recent meeting of the Société Médicale des Hôpitaux of Paris, M. Lebar reported the following case. A soldier, aged 23 years, was in a trench in Argonne which was blown up by a mine. He was projected into the air and fell, and was covered by a mass of earth, from which he succeeded in extricating himself. The detonation was such that he immediately became deaf. This was attributed to double hæmorrhagic labyrinthitis by M. Cousteaud, who subsequently examined him. The deflagration of the powder produced superficial burns of the face, and there were several bruises on the head, which were greatest on the left side. He was taken to the English hospital at Arc-en-Barrois, where on the following day he noticed, to his surprise, tufts of white hair on the left side of the head. These formed four "islets" in the left fronto-parieto-occipital region separated from one another by normal hairs. The loss of color was complete from the roots to the ends of the hairs and the longest hairs were just as white as the shortest. There was not a brown hair amidst them. The grey hairs were solidly implanted and could be pulled out only by strong traction. The bulbar swelling of the hair was equally decolorized. After the accident the patient suffered from incessant twitching of the left eyelid. The rest of the hair of the head was dark brown and there was not a white hair in the beard or moustache. The patient was an intelligent man, and the truth of his story was confirmed by the fact that his hair was described in his "livret militaire" as "marron foncé." The mechanism of sudden loss of color of the hair is not well understood. It might be suggested that in this case it was due to bleaching by gases generated by the explosion, but this was negatived by the fact that the intracutaneous parts of the hair were decolorized like the rest. The studies of Metchnikoff on the whitening of the hair due to age throw light on the question. According to him, when a hair begins to whiten there appear in the cortex round or oval cells with prolongations which gradually come into relation with the cells containing the pigment granules and absorb them. These "pigmentophages," as he calls them, then descend toward the root of the hair to scatter in the dermis, of which they are, according to him, the pigmentary cells. The pigmentophages, which originate in the medulla of the hair, disappear completely when the decoloration of the hair is achieved. This theory explains a slow and progressive decoloration of the hair of senility, and also applies to the rapid loss of color now under consideration. This rapid mobilization of the medullary cells appears to be provoked by a nervous disturbance. The place of whitening seems to be determined by the points on the scalp which have been the seat of injury. In the case reported above it was the left side of the head and face which was most injured by the explosion and the fall of earth, the labyrinthine lesions were more marked on this side, and the twitching of the eyelid was confined to this side. It was solely on the left side that the hairs were whitened. This influence of local causes is illustrated by cases which have been recorded of partial canities on parts submitted to pressure.—*The Lancet.*

A French Bomb Thrower

THE French soldiers have been improvising a very ingenious little gun for throwing bombs across the narrow space between their own and the trenches of the enemy. It is made out of a German shrapnel shell case, which is very similar to the cartridge of an ordinary rifle, but much larger. These brass shells are picked up on the battlefield, where they have been dropped after firing, and are mounted on a rude wooden frame, or on a block of wood, and a touch hole is bored in the side, near the base. To use this little gun a charge of powder in poured in, and a bomb filled with a high explosive inserted. The charge is fired through the touch hole, just like the old-fashioned cannon, and the bomb is thrown over the hundred yards or so to the hostile trench. Many of these diminutive weapons have been made by the men in the trenches, and have been found quite effective. It is claimed that these little contrivances have frequently been counted among the "captured guns" in the war reports. The French call these guns "crapouillot" because of their resemblance to a toad crouching to jump.

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